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THE THORACIC SCLERITES OF HEMIPTERA AND HETEROPTERA.*

With Notes on the Relationships Indicated.

BY LELAND H. TAYLOR.

INTRODUCTION.

This paper is intended primarily as a contribution to the morphology of the thoracic sclerites of "Hemiptera" (*sensu lato*). Incidentally it may offer some suggestions as to the relationships of the families of the order, but these can be only suggestions, since the morphology of the thorax alone can contribute but a share toward the determination of phylogeny or relationships.

But little has been written on the morphology of the Hemipterous thorax. A number of articles were found dealing with a certain family, genus, or species, but in most instances the thorax was not studied in detail and generally no attempt was made to harmonize the results with the present day conception of the thorax, or to use a terminology applicable to all insects.

Thanks are due Doctor G. C. Crampton for his assistance in interpreting the homologies of the sclerites and for the loan of valuable material to work with. His papers (Crampton, 1908-09, 1914A, 1914B, 1914C) have been indispensable in the preparation of this paper, and the nomenclature employed by him has been generally adopted here. The writer would also express his thanks to Doctor H. T. Fernald for his interest and helpful criticism.

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It has seemed advisable in this study to make drawings of at least one thoracic segment of a member of each available family of the Hemiptera. It is not necessary to present all of these, for many families resemble each other closely in the thoracic structure and separate drawings of these would be largely repetitions. One or two families, on the other hand, are omitted owing to an unfortunate lack of suitable specimens for study. The observations on the Psyllidæ as well as Figures 10 and 11 have been derived from the excellent monograph of Crawford, 1914, on that family, the present writer having been unable to secure specimens for study. Only drawings of such forms as show marked deviation from the simpler type, and of such individuals as offer features of particular interest are presented.

A slight attempt has been made at the end of the paper to group those families which from their thoracic sclerites appear to be more closely related. The grouping is made without regard to other morphological features and thus may not be entirely correct. It is hoped, however, that it may suggest, in combination with other morphological characters, some idea of the evolutional development of the Hemiptera.

Having studied only a limited number of species representing a family, the writer does not care to state that the characters of these species obtain throughout the family. For convenience, however, family names have been largely used in this paper where specific names would have been more correct, it being understood that, so used, they imply only those species studied by the writer. Nevertheless, there is apparently not much variation in a family, and one species may be considered as more or less typical of the entire family.

LIST OF FORMS STUDIED.

In the preparation of this paper the following families and their representatives were studied. The writer has not attempted to arrange these in any logical order, but has followed the sequence of families in Comstock's "Manual" for the Homoptera and that of Banks' "Catalogue of the Nearctic Hemiptera-Heteroptera" for the Heteroptera.

SUBORDER HOMOPTERA.

FAMILY	EXAMPLES STUDIED	FIGURES
Cicadidæ	Cicada tibicen	1, 2, 3, 4, 5
	Cryptotympana epithesia.	
Fulgoridæ	Fulgora sp.	9
	Ormenis sp.	8
	Amphiscepa bivittata.	
Cercopidæ	Aphrophora sp.	6
Jassidæ	Draeculacephala sp.	7
Membracidæ	Ceresa sp.	
Psyllidæ	Apsylla cistellata	10
	Arytaina robusta	11
Aphididæ	Pemphigus acerifolii	12
Aleyrodidæ	Aleyrodes vaporariorum	13

SUBORDER HETEROPTERA.

FAMILY.	EXAMPLES STUDIED.	FIGURES.
Corixidæ	Corixa sp.	19
Notonectidæ	Notonecta sp.	15, 16
Nepidæ	Ranatra sp.	17
	Nepa cinerea.	
Belostomatidæ	Belostoma americana	18, 20
	Zaitha sp.	
Reduviidæ	Sinea sp.	
Emesidæ	Emesa sp.	14
Nabidæ	Corsicus sp.	24
Cimicidæ	Cimex lectularius.	
Gerridæ	Gerris sp.	21
Capsidæ	Poecilocapsus sp.	
Phymatidæ	Phymata sp.	
Tingitidæ	Corythuca sp.	
Lygaeidæ	Lygaeus sp.	
Berytidæ	Neides sp.	22
Coreidæ	Anasa tristis	23
	Metapodius sp.	
Pentatomidæ	Brochymena sp.	
	Podisus sp.	
Thyreocoridæ	Thyreocoris sp.	25

GENERAL CONSIDERATIONS.

The Hemipterous thorax, while peculiarly developed in its higher forms, is in the more generalized individuals easily comparable to that of other insects. Indeed, the points of similarity between the thorax of *Cicada* and that of certain Neuroptera (*Mantispa* or *Corydalis*, for example) are very marked. In each of these forms the notum is similarly divided. Homologous plates occur at the base of the wings of each. The pleura, particularly, of these forms resemble each other, the episterna and epimera being in all cases divided into upper and lower portions by sutures. In certain Neuroptera, also, we find a third, median sclerite in the episternum homologous with a similar piece in certain Cicadidæ. The coxæ and sterna are also much alike in both Neuroptera and Cicadidæ.

DESCRIPTION OF A GENERALIZED HOMOPTEROUS THORAX.

Suborder Homoptera, Family Cicadidæ; *Cicada tibicen*, *Cryptotympana epithesia*. Figures 1, 2, 3, 4, 5.

These insects have been selected for detailed description as being probably rather primitive Hemiptera. They have the additional advantage of being comparatively large and therefore easy to study.

Between the thorax and the head are three pairs of small, free plates, the cervical intersegmentalia (Figures 2 and 3, is). These probably belong, partly to the head, partly to the prothorax. They may all be included under the term veracervix of Crampton, 1914B.

Prothorax. Figure 3.

This segment, as compared with the prothorax of the more specialized forms, is small, overlapping only a slight portion of the mesothorax.

Notum. Figure 3. The notum or tergum occupies the larger part of this segment, extending downward laterally for a considerable distance. There is a narrow pretergite (pr marked off on the anterior margin and connected with the pleuron by a lateral extension which is homologous with the prealare (pra) in the wing bearing segments. There are no distinct sutures in the pronotum, but there are several grooves or furrows which mark off a triangular prescutum (psc), a scutum (sc), which is narrow mesally and widens as it approaches the pleuron, and a scutellum (sl), a rectangular band along the rear margin of the segment. The postscutellum is probably not represented in this segment.

Pleuron. Figures 2 and 3. The pleuron of the prothorax is much reduced and is closely joined to the notum. It is divided into an anterior portion, the episternum (es), and a posterior portion, the epimeron (em), by a short pleural suture (p). The episternum is small and is connected with the sternum by a narrow precoxal bridge, the precoxale (pcx), from which it is not distinctly separated. The epimeron is larger, overlapping the mesopleuron to some extent. It likewise is joined to the sternum, by a postcoxal bridge, the postcoxale (poc). The trochantin (tn) is rather broad, and when in position partly overlaps the base of the coxa (cx).

Sternum. Figures 2 and 3. The sternum (st) of the prothorax is narrow from front to rear and apparently consists of but one sclerite, which bears the furca, an interior projecting fork for muscle attachment. The coxa is divided into a front portion, the veracoxa (vcx), and a rear portion, the meron (me).

Mesothorax. Figures 1, 2 and 4.

The mesothorax is by far the largest and most typical segment.

Notum. Figures 1 and 4. The mesonotum, as in most insects, is divided primarily into two distinct plates. The first, which is that part of the notum visible externally, is roughly pentagonal in shape and is called the scuto-scutellum by Crampton, 1914A, 1914B. This portion has often been called notum, but this term should be applied only to the whole dorsal region of the segment. The second primary division of the notum is the postscutellum, which is concealed behind and somewhat beneath the scuto-scutellum, and hence is not shown in the figures.

The scuto-scutellum is in turn subdivided by various infoldings of chitin into several parts. The foremost of these is the anterior phragma (aph), which projects under the pronotum and is connected with it by membrane. Immediately behind this is the pretergite (prt), which is narrow and is fused with the rather large, bilobed prealare (pra) on either side. The latter, as is usual in the Hemiptera, connects the notum with the pleuron, anterior to the wing. Two distinct, nearly longitudinal sutures, which approach each other posterior to the middle of the tergum, mark off the prescutum (psc). The scutum (sc) is an ill-defined region just posterior to the prescutum, extending downward on either side and forming the major part of the whole scuto-scutellum. Where the scutum articulates with the wing base a small piece, the suralare or supralare (sr), is partly marked off by a cleft extending forward. (In some insects this piece is entirely separated from the scutum by a suture.) Another cleft extending backward partly defines a similar piece. These two pieces articulate with a free plate, the notopterale (npt), which forms one of the principal connections with the wing. The tegula (tg) in the Cicada is poorly chitinized, but its homologue is clearly seen in the membrane anterior to the base of the fore wing (Figure 1). A broken suture nearly parallel with the posterior margin of the scuto-scutellum demarks the scutellum (sl). The posterior edge of the scutellum is produced on either side to a point which connects with the anal margin of the wing. Just anterior to this point, imbedded in the membrane, occurs a small triangular plate, the adanal pterale (apt), articulating with the bases of the anal veins. The postscutellum is a narrow piece entirely concealed beneath the edge of the scutellum and fused with the anterior phragma of the metathorax. It is connected with the mesoepimeron by a narrow postalar bridge (Figure 4, poa). This has been termed pleurophragmite, pleurotergite, and postalare by various authors. The term postalare appeals to the present writer, as there is a corresponding prealar in front of the wing.

Pleuron. Figures 2 and 4. The mesopleuron of the Cicada is decidedly primitive and resembles the condition found in certain Neuroptera. The pleural suture (p) is particularly distinct, extending from the wing base to the articulation of the coxa. The episternum (es) is divided by a suture (a) into an upper and a lower region, called respectively the anepisternum (aes) and the katepisternum (kes). The upper portion has often been wrongly designated as the whole episternum, but, as Crampton, 1914A, 1914B, has shown, the episternum always extends the entire length of the pleural suture. The anepisternum (aes) is partly divided vertically by a cleft running about parallel to and near the pleural suture. In *Cryptotympana epithesia*, a large Sumatran Cicadid, and probably in other forms, a median portion (mes), in addition to the upper and lower parts, is marked off on the episternum by sutures. A similar condition is to be observed in certain Neuroptera.

The katepisternum (kes), the precoxale, or precoxal bridge (pcx), and the sternum are indefinitely fused. Above the episternum at the base of the wing is a free sclerite, the posterior basalare (pba). Another plate a little in front of and below this sclerite is the anterior basalare (aba), which is only partly separated by a cleft from the episternum. The spiracle of the mesothorax is located anterior to the prealare and is surrounded by a chitinous plate, the peritreme (pt).

The epimeron (em), like the episternum, is divided into an upper region (aem) and a lower region (kem) by a prolongation (b) of the suture which divides the episternum. These regions have been designated variously as hyperepimeron or anepimeron the upper) and hypoepimeron or katepimeron (the lower) by Crampton, 1908, 1909. The same writer (Crampton, 1914B) has used the term pteropleurite for the upper part, this being a modification of Osten-Sacken's, 1884, term pteropleura of the Diptera. It seems reasonable, if we decide on the prefixes ana- and kata- for the two divisions of the episternum, to employ the corresponding terms anepimeron and katepimeron in this instance. These terms are both self-descriptive and logical, while pteropleurite might be taken to mean a part of the episternum.

The connection of the epimeron with the postscutellum (i. e., the postalare) has already been mentioned. This is always strongly fused with the epimeron and usually no suture is to be seen between the two. A postcoxal bridge, the postcoxale (poc), connects the katepimeron with the sternum. Above the epimeron at the wing base two plates, the anterior (asa) and the posterior subalares (psa), occur, supporting the anal region of the wing. The trochantin (tn) of the mesothorax is semicircular and rather broad. A continuation of the pleural suture in the coxa partly marks off the meron (me) from the veracoxa (vcx).

Sternum. Figures 2 and 4. The mesosternum consists of but two well defined sclerites, the basisternite (bs) and the furcasternite (fs).

Smith and Grossbeck, 1907, in figuring the ventral view of *Cicada tibicen*, have apparently misinterpreted the parts of the prothorax and the mesothorax. In a figure similar to the writer's Figure 2 they have called the mesothoracic anepisternum (aes$_2$) the proepimeron; they have designated the metathoracic katepisternum (kes$_2$) as the entire mesosternum; the mesothoracic anepimeron (aem$_2$) has been called mesoepisternum; and the mesothoracic katepimeron (kem$_2$) has been termed the entire mesoepimeron. The median sclerite (mes$_2$) of the mesothoracic episternum is labelled proepisternum. A comparison of the ventral view with the lateral aspect of the thorax of this insect will instantly establish the true relation of these parts, though it may not be apparent from the ventral view alone.

Metathorax.

The metathorax is similar in general make-up to the mesothorax.

Notum. Figure 5. The notum of the metathorax is narrow from front to rear. The prescutum (psc) is but a narrow band. The scutum (sc) is narrow at the summit and broadens as it reaches the wings. The scutellum (sl) is ill defined at the summit. It is produced laterally into a narrow band bearing the axillary cord, which is continuous with the anal margin of the wing. The postscutellum (psl) is also narrow and is joined by the postalare (poa) to the epimeron (em).

Pleuron. Figure 5. The metathoracic pleuron is divided by a distinct pleural suture (p). The episternum (es) is undivided and is fused ventrally with the precoxale (pcx). The posterior basalare (pba) rests on the anterior basalare (aba), while the latter rests on the episternum (es); all are closely united, but the sutures demarking them are distinct. A wide peritreme (pt) joined to the episternum surrounds the spiracle. The epimeron (em) of the female is large and rectangular. In the male a broad lobe (op), called sometimes the operculum, extends backward from the epimeron and sternum, forming a cover for the tympanum or sound producing organ. In either case the postcoxale is indistinct. An anterior (asa) and a posterior subalare (psa) support the anal part of the wing as in the mesothorax. The trochantin (tn) is long and narrow in this segment.

Sternum. Figures 2 and 5. The sternum of the metathorax consists of basisternite (bs_3, Figure 2; bs, Figure 5) and furcasternite (fs_3, Figure 2). The latter region together with the episternum is prolonged posteriorly to cover the tympanum in the male. The meral region (me) of the coxa bears on its posterior side a flattened spine or spur (mc), called by Fieber, 1875, the meracanthus.

MODIFICATIONS IN OTHER HOMOPTERA.

It is difficult to trace the development of the Homoptera along definite directions toward the various modifications which characterize the higher forms. All the families show close relation to each other, but most of them possess striking features not comparable or traceable to features in others. The following are among the more striking modifications occurring throughout the Homoptera.

Prothorax. Figures 10 and 11.

The prothorax of Membracids is developed to extreme proportions. It covers a good part of the mesothorax and extends dorsad nearly to the tip of the abdomen, terminating in a point. In the other families the prothorax is similar to that of *Cicada* (Figure 3), except that in the Psyllidæ (Figures 10 and 11), Aphididæ, Coccidæ and Aleyrodidæ it is even more collar like, scarcely overlapping the mesothorax.

Between the prothorax and the mesothorax of Psyllidæ (Figures 10 and 11) there are, according to Crawford, 1914, three small sclerites. One of these, the lower, is the peritreme (pt) surrounding the spiracle. Above this and often separated from it only by a line is a second sclerite (pt) which is probably part of the peritreme. The third of these sclerites (it) occurs behind the above mentioned two, and its origin is not easily traceable. Crawford, 1914, calls it an accessory sclerite. It would, however, probably come under the term intersegmentalia used by Crampton, 1914A, 1914B, and would thus be termed intertergite. Its homologue was not found in any of the forms treated in this paper.

Mesothorax. Figures 7, 10, 11 and 12.

Notum. The mesonotum in the other Homoptera differs only in detail from that of *Cicada*. The primary divisions—prescutum (psc), scutum (sc), scutellum (sl) and postscutellum (psl)—are always present. A well chitinized and fairly large tegula occurs in the mesothorax of Fulgorids (*Fulgora* sp.), but is not present in other families of Homoptera.

Pleuron. In the pleuron of the mesothorax several differences are noticeable. The basalares (aba, pba) disappear or become fused to the episternum in some families. The beginning of this is observable in *Cicada*, where the anterior basalare (aba) is only partly separated from the episternum by a cleft or notch. In the Fulgoridæ, Jassidæ (Figure 7) and Membracidæ no free basalares are to be seen, though one at least is probably present, fused with the episternum. On the other hand, there are usually two basalares (aba, pba) in Psyllids, (Figures 10 and 11), in the Aphids there is at least one (pba), and though they could not be detected by the writer on account of poor material, it is not improbable that one or two occur in the Coccids and Aleyrodids. The pleural suture (p) of the mesothorax is usually distinct among the Homoptera. In some Psyllids, however, it extends but halfway up the pleuron from the coxal attachment. The cleft or notch mentioned as running parallel to the pleural suture in the mesoepisternum of the Cicadidæ persists in the Fulgoridæ, the Jassidæ (Figure 7) and the Membracidæ, greatly reduced. In the Aphididæ (Figure 12) it is even deeper and in the Psyllidæ (Figures 10 and 11) a probable trace of it remains.

The episternum in the Jassidæ (Figure 7) is subdivided into three parts (aes, mes, kes) as in the Cicadidæ, but in most of the other Homoptera all trace of these divisions is lost. In the Aphididæ (Figure 12) the episternum (es) of the mesothorax is divided into an upper and a lower portion, the anepisternum (aes) and the katepisternum (kes),* as in Cicadidæ, Jassidæ and Neuroptera, but the median plate is not present. In the Jassidæ (Figure 7) a narrow band (hyp) is marked off in front of the episternum and is produced into the sternum. This has been shown by Crampton, 1914C, to be the hypopteron of Audouin, 1820, termed the pre-episternum by Snodgrass, 1909. As in the Cicadidæ, the episternum is not separated from the sternum in the Fulgoridæ, Cercopidæ, Jassidæ, Membracidæ and Aphididæ. The mesothoracic trochantin (tn) is readily seen in all the families studied except the Psyllidæ, Aphididæ and Aleyrodidæ.

The epimeron does not present many differences among the Homoptera. The homologue of the suture dividing the epimeron of *Cicada* into upper and lower parts, however, has not been found in other families.

Sternum. The sternum of the mesothorax is considerably lengthened in all forms except the Membracidæ, where both mesothorax and metathorax are much condensed from front to rear. The coxa of this segment in the Fulgoridæ and the Cercopidæ bears sometimes a spur or meracanthus.

Metathorax. Figures 6, 8, 9, 10, 11, 12 and 13.

Notum. The notum of the metathorax in other Homoptera is usually longer than that of Cicadidæ. It is often shortest along the mid-dorsal line and longest as it approaches the wings. In the Aphididæ and the Psyllidæ this is not generally true, the median length of the notum being usually greater than the length of the lateral margin. In the Jassidæ the metanotum is nearly as long as the mesonotum.

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*Attention is called to an error in labelling in Figure 12. The abbreviation kes$_2$ should refer to that part of the plate marked pcx$_2$ which is just anterior to the pleural suture (p$_2$). The abbreviation pcx$_2$ would then refer to an indefinite portion of this plate between kes$_2$ and the posterior part of st$_2$.

Pleuron. The metathoracic pleuron exhibits several points of difference from the primitive type. In the lower part of the episternum of the Cercopidæ (Figure 6) will be noticed a short suture running parallel to the pleural suture. In the Fulgoridæ (Figures 8 and 9) this suture is possibly represented by a membranous cleft, to be described later. The metapleuron, metasternum and metacoxa of the Fulgoridæ (Figures 8 and 9) present a very remarkable and puzzling condition. Hansen, 1890, figured and described the coxa and its surrounding parts, but was mistaken in his interpretation of the boundary of the coxa. He did not consider the upper portion of the part labelled meron (me) in Figures 8 and 9 as a part of the coxa. Since this plate bears muscles extending to the subalar region and such muscles characteristically connect the meron with that region in other insects, it is unquestionably a part of the coxa. The coxa is, indeed, so fused with the pleuron and sternum as to make these parts extremely difficult of interpretation. Added to this confusing state is the substitution of a considerable amount of membrane for chitin in these parts. On comparing Figures 8 and 9 it will be seen that there is a marked variation in the two forms. Essentially, however, they are very similar. In *Ormenis* sp. (Figure 8) the parts can be more easily identified. It will be noticed that in this form the coxa (cx) extends dorsally to a point not far from the wing base and that a lobe of the episternum covers the anterior part of the coxa to some extent. This lobe being transparent, the true limits of the coxa can be distinguished through it. That the coxa extends posteriorly to the point indicated in the figures is shown—as mentioned above—by the presence of characteristic muscles running from the subalar region to the meral region (me) of the coxa.

The coxa, then, in Fulgoridæ is rather extensive; it is divided into a true coxa, or veracoxa (vcx), and a large meron (me), which in turn is divided into two parts. The coxa is, moreover, immovable as a result of its close fusion with the other parts. The large non-chitinous areas in the pleural and sternal regions, however, probably impart a certain elasticity to the coxa, which doubtless compensates for its immobility to some extent. These membranous areas are to be found in the episternum, the epimeron and the sternum. In the episternum the membranous portion forms a cleft, nearly bisecting the plate. In the epimeron a similar cleft is found, but this is nearly surrounded by chitin and does not open broadly as does that of the episternum. The sternum, save a small anterior plate and a piece between and behind the coxæ, is almost entirely membranous.

In the Cercopidæ (Figure 6) there occurs in the lower epimeron, partly covering the meron of the coxa, a flap-like process, which may be the homologue of a similar process on the lower epimeron of Fulgoridæ (Figure 9).

Also meriting particular mention are the pleuron, sternum and coxa of the Psyllid metathorax (Figures 10 and 11). In the generalized forms, *Apsylla* (Figure 10) for example, the pleuron and coxa are not radically different from those of other Homoptera, but in certain higher forms like *Arytaina robusta* (Figure 11) some remarkable conditions obtain. The pleuron, particularly the epimeron (em), is greatly reduced, while the coxa (cx) has become enormous. The pleural suture (p) no longer extends from the wing articulation to the coxal condyle, but seems to end arbitrarily on the lower margin of the pleuron. The coxal articulation (x) occurs at the center of the lower margin of the greatly reduced epimeron (em). The pleuron and coxa thus present the appearance of the latter having become extended far up the side of the body, replacing the former to a great extent. In this shifting the coxa seems to have carried with it along the lower margin of the pleuron its articulatory process (x), which in other forms, is almost universally found at the end of the pleural suture. In the Psyllids there is no distinct precoxale in the metathorax, but the narrow postcoxale (poc) is remarkably long and distinct. It is possible that the large trochantin (tn_3) figured by Crawford, 1914, may be a region homologous with the precoxale found in other forms. The coxa bears on its lower posterior side an articulated meracanthus (mc).

In the metathorax of Aleyrodidæ (Figure 13) the pleural suture (p) is only partly distinct, the upper part being wanting. A continuation of the pleural suture extends the entire length of the coxa, which is apparently fused with the pleuron.

Sternum. The sternum of Psyllidæ is represented by a very narrow sclerite between the coxæ, hardly visible from the side. Aside from this and the modifications noted above in the Fulgoridæ, the metathoracic sternum is fairly normal.

DESCRIPTION OF A GENERALIZED HETEROPTEROUS THORAX.

Suborder Heteroptera, Family Belostomatidæ; *Belostoma americana. Zaitha* sp. Figures 18 and 20.

The giant water bug (*Belostoma americana*) is described rather fully here, since it is a somewhat generalized Heteropteron. It is also of a convenient size to study and it is widely distributed.

Prothorax.

This segment, as in most Heteroptera, is somewhat collar like, fitting tightly to the head and closely overlapping the anterior part of the mesothorax. The notum is trapezoidal in outline and is rather large. The pleural region is somewhat broad above, narrowing to meet the narrow sternum. Rarely is the prothorax distinctly marked off into sclerites, and it is fundamentally so similar in all Heteroptera, that it will require but little mention.

Mesothorax. Figure 18.

Notum. The notum of the mesothorax does not show a distinct pretergite, this sclerite being probably represented by part of the anterior phragma (aph). The prescutum (psc), a semicircular piece, is marked off clearly. Extending in front of the wing from the lateral margin of the prescutum is a bilobed prealare (pra), the anterior lobe of which joins an upward projection of the sternal region. No separating suture occurs between scutum (sc) and scutellum (sl). The latter is produced backward to a point over the metanotum. A postscutellum (psl) is concealed under the scutellum and is connected by the postalare (poa) with the epimeron. Snodgrass, 1909, at first stated that no postscutellum was present in the mesothorax of of *Belostoma*. Later (Snodgrass, 1910), however, he noted the presence of this sclerite.

Pleuron. The mesopleuron in this and in other Heteroptera has the appearance of having been distorted from its normal form, i. e., the upper part seems to have been pushed forward, or the lower part backward. This brings about two remarkable conditions: first, the pleural suture (p) becomes almost horizontal, and second, the coxa (cx) extends outward from the rear of the segment instead of from beneath. Another peculiarity of this and other members of the suborder is the overlapping of the base of the coxa by the lower parts of the two pleural plates. The episternum (es) is long and somewhat narrow. Its lower portion lies virtually below the coxa (cx) and hence has been called the subcoxal plate by some authors. It is evident, however, that it is really but a part of the episternum. Fused to the anterior (or to what is normally the dorsal) end of the episternum, the homologue of at least one of the two basalar plates (aba) occurs. The posterior basalare may also be present. The epimeron (em) is triangular in shape and lies above the episternum. It is produced posteriorly to a sharp point, which overlaps the metapleuron and bears dorsally a knob-like projection. This projection fits into a socket in the closed forewing to hold it fast.

Sternum. Owing to the aforementioned shifting of the pleural plates, the sternum lies along what would naturally be the anterior margin (but actually is the lower margin) of the episternum. The coxa (cx), as has been stated, proceeds from the rear of the segment, the attachment being concealed beneath the pleuron at a point marked (x). The trochantin is hidden beneath the episternum.

Metathorax. Figure 20.

Notum. The notum is not long mesally, but it lengthens as it reaches the wing. It is largely composed of the prescutum (psc) and the scutellum (sl), the other plates not being clearly defined, though the scutum (sc) is probably represented. The postscutellum (psl) is concealed and is fused with the narrow first abdominal tergite. The postalare (poa) is unusually broad where it joins the epimeron.

Pleuron. The pleuron of the metathorax overlaps the coxa to some degree. Like the mesopleuron, it is turned or twisted so that the pleural suture (p) is nearly horizontal. The episternum (es) is divided into an upper (aes) and a lower section (kes), but these may not be homologous with similar divisions in the mesopleuron of *Cicada* and related forms. The lower portion (kes), often designated as the subcoxal plate, is produced backward in a pointed flap, which reaches two-thirds the length of the coxa. The epimeron (em) is small, triangular and pointed posteriorly.

Sternum. The metasternum (st) is not clearly separated from the episternum. It is very similar to the sternum of the mesothorax. The hind coxa (cx) is very large.

MODIFICATIONS IN OTHER HETEROPTERA.

As in the Homopterā, it is difficult to trace the modifications in the higher Heteroptera along definite lines of development. Unlike the Homoptera, however, the higher families of Heteroptera show considerable departure from the primitive type, and resemble only slightly the Belostomatidæ and their near relatives. Of the forms studied only the Corixidæ (Figure 19), Notonectidæ (Figures 15 and 16), and Nepidæ (Figure 17) show characters very similar to *Belostoma*. The Nepidæ seem in a number of ways to be a connecting link between these and the more modified forms.

Before commencing the discussion of the modifications of the thorax in the Heteroptera, it may be well to mention Heymons', 1899, interpretation of the thorax of *Nepa cinerea*, since this work is frequently referred to by other writers. In the later larval stages, which he studied and figured, the body is much flattened dorso-ventrally. The pleural plates are thus apparently ventral. Heymons has hence called the episternum of the various segments the "lamina subcoxalis" or subcoxal plate (Subcoxalplatte), since its true position is beneath the coxa. The mesothoracic epimeron is a sickle-shaped flap, which extends beyond the hind coxa. This sclerite was considered by Heymons to be the metathoracic "pleurite," but that it is most certainly the mesothoracic epimeron is clearly seen by lifting the flap and observing its attachment. A sclerite which Heymons designates as paratergite, the writer believes from its location to be the metathoracic epimeron.

Prothorax.

This segment is fairly constant throughout the group. It may vary in size and shape, but in its ground plan it is essentially the same in all the families studied. It is of minor importance in the study of the sclerites, and is not figured in this paper. One notable exception obtains in the Gerridæ, where the scutellar region of the pronotum extends so far back as to entirely cover the mesonotum.

Mesothorax. Figures 14, 15, 17, 18, 19, 21, 22, 23, 24 and 25.

Notum. The notum of the mesothorax in the suborder Heteroptera is usually divided by sutures into pretergite (prt), prescutum (psc), scutum (sc), scutellum (sl) and postscutellum (psl). In most families the scutellum (sl) is very prominent, and is always to be seen between the closed forewings, extending backward over the succeeding segment and terminating usually in a point. In some forms the scutellum (sl) becomes unusually extensive. In the Pentatomidæ it reaches beyond the metathorax and projects over the abdomen, in the Scutelleridæ it extends still farther, while in the Thyreocoridæ (Figure 25) it almost conceals the abdomen. The postscutellum (psl) is always closely attached to the anterior part of the next segment so that it is frequently difficult to ascertain its posterior limit. A prealare (pra) is almost invariably found in the mesothorax throughout the Heteroptera, and together with the antero-lateral margin of the mesonotum and the upper anterior margin of the mesopleuron, it forms the boundary of an irregular, often more or less triangular, membranous region (i. e., the region posterior to pra, ventral to psc and dorsal to aba and es). In front of the prealare (pra) the spiracle, surrounded by its peritreme (pt), is usually to be seen. The postalare (poa) is usually narrow and often almost indistinguishably fused with the prescutum (psc) of the metathorax.

Pleuron. The mesopleuron exhibits a considerable degree of diversity in the suborder. Along the upper margin of the episternum (es) there is usually marked off a narrow plate (aba), probably the anterior basalare, which has become fused to the episternum. This fusion occurs in most Heteroptera. Often the posterior basalare (pba) is also distinguishable, usually above the anterior basalare; this, too, is often fused to the episternum. This plate (pba) occurs in the Emesidæ (Figure 14), Berytidæ (Figure 22) and Coreidæ (Figure 23).

In nearly all the Heteropterous families studied (except in the Notonectidæ, Nabidæ, Cimicidæ and Capsidæ) the pleural plates extend down over the upper part of the coxa (cx). In such cases the lower part of the pleuron is divided by a cleft (c) extending lateral to the coxa and terminating in the coxal articulation (x). From this coxal process, as the articulatory projection of the pleuron is called, the pleural suture, when present, extends dorsad. In the Heteroptera it is more often absent, being entirely visible only in the Corixidæ (Figure 19), Notonectidæ (Figures 15 and 16) and Belostomatidæ (Figure 18). In the Nepidæ (Figure 17), Capsidæ, Reduviidæ, and Thyreocoridæ (Figure 25) it is visible in part, extending dorsalward from the coxal articulation (x) to a point about midway up he pleuron. The division of the pleuron is usually indicated n the inner side of the plate by a ridge, the internal representative of the pleural suture, even when the pleural suture itself s entirely absent. It must be mentioned here that the coxal cleft in the metathorax does not occupy a position homologous with that in the mesothorax and hence cannot be taken as a "landmark" for the separation of episternum and epimeron in hat segment.

In the Nepidæ (Figure 17) and the Thyreocoridæ (Figure 25) the episternum of the mesothorax is divided into anepisternum (aes) and katepisternum (kes), a condition not general with the Heteroptera, but met with in Cicadidæ, Jassidæ and Aphididæ, among the Homoptera.

The distorted condition remarked above in connection with *Belostoma* is noticed also in the Corixidæ (Figure 19) and Notonectidæ (Figure 15). The backward projecting flap of the epimeron of *Belostoma* finds its homologue only in the Nepidæ Figure 17), though in most forms the posterior margin of the epimeron overlaps more or less the anterior part of the next segment. In the higher Heteroptera, among them the Reduviidæ, Emesidæ (Figure 14), Nabidæ (Figure 24), Gerridæ Figure 21), Capsidæ, Phymatidæ, Lygæidæ, Berytidæ (Figure 22), Coreidæ (Figure 23) and Pentatomidæ, the shape of the mesopleuron, and usually of the metapleuron is rectangular. The coxa (cx) retains its position at the rear of the segment even n the elongated forms, *Emesa* (Figure 14), *Gerris* (Figure 21) and *Neides* (Figure 22), for example. In the Gerridæ (Figure 21), where the body is very nearly cylindrical, the mesocoxa cx$_2$) is partially encased by a cylindrical, bulging socket. The coxal cleft (c$_2$) runs the length of this socket. A trochantin (tn, Figure 15) is very probably present in most of the Heteroptera, though its position beneath the episternum prevents it from being easily detected.

Sternum. The mesothoracic sternum is usually indistinguishably fused with the pleuron, and consists apparently of a single sclerite. In some instances, namely in the Notonectidæ Figure 15), Reduviidæ, Emesidæ (Figure 14), Cimicidæ, Phymatidæ and Tingitidæ, a faint line more or less distinctly marks off the sternum from the pleuron.

Metathorax. Figures 14, 16, 19, 20, 21, 22, 23, 24 and 25.

Notum. The metanotum varies in the Heteroptera from a size nearly equal to that of the mesonotum to a small section almost entirely concealed under the scutellum of the mesothorax. The pretergite (prt), if present, is indistinguishably fused with the posterior phragma of the mesothorax. A narrow prescutum (psc) is often visible, but it is closely united with the mesothoracic postscutellum (psl_2) often adhering to it when the mesothorax and metathorax are pulled apart. Prescutum (psc), scutum (sc) and scutellum (sl) are sometimes, as in the Corixidæ (Figure 19), Notonectidæ (Figure 16), Nabidæ (Figure 24), Cimicidæ and Berytidæ (Figure 22), inseparably fused together. In some cases, on the other hand, one, two, or all three of these sclerites are definitely marked off by sutures. The postscutellum (psl) is found in all gradations, from a brief, partially hidden plate, as in *Belostoma* (Figure 20), to a large, extensive sclerite, as in the Berytidæ (Figure 22).

In the Gerridæ (Figure 21) the homologies of the parts of the metanotum are not easily determined. There is apparently a short plate composing the scutoscutellum (ssl_3), rather long mesally and coming forward to a point on either side to reach the narrow wing bases, which are set somewhat forward. Behind this is the rather extensive postscutellum (psl_3), likewise extending forward in a point on each side, and very broadly joined to the epimeron (em_3).

In the Coreidæ (Figure 23) and similar forms a narrow, raised portion (ce_3), the cenchrus of Hemipterologists, extends along the upper margin of the epimeron (em_3) where the postalare (poa_3) joins it. This is possibly homologous with the parapleuron of Coleopterologists.

Pleuron. The pleuron of the metathorax is in general similar to that of the preceding segment. The distorted condition mentioned above is most noticeable in the Corixidæ (Figure 19), Notonectidæ (Figure 16) and Belostomatidæ (Figure 20). In *Corixa* (Figure 19) the coxa (cx_3) is very large and its base is covered by flaps of both episternum (es_3) and epimeron (em_3). The pleural suture (p_3) is nearly horizontal and lies very near the upper margin of the pleuron. The epimeron (em_3) is thus very narrow. Only in *Belostoma* (Figure 20) is the metathoracic episternum divided into anepisternum (aes) and katepisternum (kes). In *Notonecta* (Figure 16) and in *Belostoma* (Figure 20) the epimeron (em) does not overlap the coxa, but the episternum es projects backward over it for some distance. With few exceptions, notably in the Nabidæ (Figure 24) and Cimicidæ, and possibly in some others, the coxæ (cx) of all Heteroptera are partially overlapped by the metapleural plates, the coxal attachment (x) being concealed and its position not usually recognizable externally. In *Gerris* (Figure 21), an elongate, cylindrical form, the base of the coxa is set in a bulging socket, as in the mesothorax, except that there is no cleft in this socket. In *Emesa* (Figure 14), another elongate form, the base of the hind coxa (cx$_3$) is partly covered by a pointed flap, while another pointed flap lies behind it.

The pleural suture (p$_3$), except in *Corixa* (Figure 19), *Notonecta* (Figure 16) and *Belostoma* (Figure 20) is absent in the metathorax of all forms studied. A coxal cleft (c$_3$) is often present, as in the Nepidæ, Berytidæ (Figure 22), Coreidæ (Figure 23) and many other forms, but it is not to be homologized with the coxal cleft (c$_2$) of the mesothorax, since it does not terminate at the coxal process (x), but is usually located in front of and below the coxa. Hence it is incorrect to use the metathoracic coxal cleft (c$_3$), as some writers, (Tower, 1914, for example) have done, as a "landmark" for separating episternum (es$_3$) and epimeron (em$_3$). The episternum (es$_3$) and epimeron (em$_3$) are always to be separated by the pleural suture (p$_3$), and when this is absent, as it is in these forms, we must take as a basis for the division of the pleuron, the two points which are the constant limits of this suture when it is present. Thus the episternum and epimeron can be exteriorly separated only by an imaginary line, representing the pleural suture, extending from the wing fulcrum to the articulation of the coxa (x). This conclusion is strengthened by the fact that on examination of the interior surface of the pleuron in certain forms where no pleural suture exists, one will find a more or less distinct ridge, extending in an irregular, but fairly definite line between the wing fulcrum and the coxal process. Now in all forms possessing a pleural suture there is to be found on the inner surface of the pleuron a corresponding pleural ridge, this ridge being the internal manifestation of the external pleural suture. Hence it is not incorrect to use this ridge, which is as constant as the suture, as a "landmark" in naming the pleural plates. The ridge has been represented by a dotted line in the figure of the squash bug (Figure 23). It would probably be found in other forms where the pleural suture is absent, extending in a similar direction.

The general shape of the metapleuron in those forms where the pleural suture is absent is rectangular. In many forms the upper forward margin of the metathoracic pleuron extends slightly beneath, or at least anterior to the rear margin of the mesothoracic pleuron. This is true of the Nabidæ (Figure 24), Gerridæ (Figure 21) and Berytidæ (Figure 22) and of other forms not figured. It is particularly well shown in *Gerris* (Figure 21), where the rear wing lies very far forward, and the pleuron extends beyond it to support it.

In one of the elongate forms, *Emesa* (Figure 14), the epimera (em_3) of each side present the appearance of meeting dorsally and bridging the region behind the postscutellum (psl_3). Though this may seem an improbable conception, it may not be an impossible one, since it will be recalled that in the mesothorax of Odonata the two episterna meet in front of the notum in much the same fashion.

Openings of scent glands (sg) occur in a number of families. These are represented in the figure of the squash bug (Figure 23). The opening is located at the end of the coxal cleft (c_3) in the lower anterior corner of the episternum (es_3).

Sternum. The metasternum is quite like the mesosternum in the Heteroptera. It consists of one plate (st_3) usually and is not often separated from the episternum. A narrow postcoxale (poc_3), usually concealed, passes behind the coxa (cx_3) from epimeron (em_3) to sternum (st_3). This postcoxale is externally visible in *Coriscus* (Figure 24, poc_3).

RELATIONSHIPS OF THE HEMIPTERA INDICATED BY THE THORACIC SCLERITES.

On account of the diversity in the thoracic structure of Hemiptera, it is difficult to interpret the relationships of the families. Moreover, there are in the sclerites of some forms modifications, the origin of which is uncertain, there being apparently no intermediate or ancestral conditions leading up to these modifications in the forms studied. Hence it has been possible only to group together certain families whose thoracic sclerites most resemble each other.

Among the Homoptera the Cicadidæ exhibit certain features in common with the Jassidæ, of which the most striking is the

Neuropteroid mesothoracic episternum. The general plan of the Cicadid thorax is followed in the Aphididæ, Membracidæ, Psyllidæ, Cercopidæ and Fulgoridæ. Of these, however, all but the Aphididæ and perhaps the Psyllidæ present striking modifications, such as the extreme specialization of the Membracid prothorax, and the remarkable fusion of the coxæ and the metathoracic pleura of the Fulgoridæ, the latter of which seems to have originated in a similar condition (less marked) in the Cercopidæ. The Membracidæ and Fulgoridæ, therefore, seem to be nearly related with respect to the thorax. The thorax of the Aleyrodidæ, being extremely small and lacking in pigment, cannot be carefully compared with that of the other families. Its large metathoracic coxa, immovably fused with the pleuron, may connect it with the Fulgoridæ. The following diagram illustrates to some extent the relationships shown by the thorax, without regard to primitiveness.

Cicadidæ	Neuropteroid thorax	Similar thoracic plan with but few modifications.	Similar general thoracic plan.
Jassidæ			
Aphididæ			
Psyllidæ			
Membracidæ	Specialized prothorax		
Cercopidæ	Peculiar fusion of metathoracic sclerites and coxæ		
Fulgoridæ			
Aleyrodidæ			

In the Heteroptera the thoracic structures of all the families are similar in their general composition. The relation of the coxæ to the pleural plates differs to some extent and may in a way serve to indicate some of the more general relationships. The Notonectidæ, Corixidæ, Belostomatidæ and Nepidæ are apparently related, both because of the distorted condition of the thorax, mentioned above, and from the large size of the metacoxa, which is overlapped more or less by the pleural plates. The remaining families studied in this paper seem very similar in the construction of the thorax. In the Capsidæ, Nabidæ and Cimicidæ the mesothoracic and metathoracic coxæ are entirely exposed, or nearly so, not being overlapped by the pleural plates. The relation of the Cimicidæ to the other two is somewhat problematic, the flattening of the thorax and consequent contraction of the thoracic plates giving these insects a unique place in the order. The Reduviidæ and Phymatidæ, unlike any others of the families studied, have a true coxal cleft in the metathorax, homologous with that in the mesothorax. The Pentatomidæ, Scutelleridæ and Corymelænidæ may be grouped on account of the extremely developed mesothoracic scutellum, which projects far over the abdomen. The chief reasons for uniting the Berytidæ and Gerridæ in the diagram below are the horizontal lengthening of the mesopleura, and the metathoracic scutellum, which in both joins broadly with the epimeron ventrad. The Emesidæ also resemble these two families, though their relation to them may be questioned. The following diagram is an attempt at grouping those Heteropterous families, which appear from their thoracic sclerites to be related.

Notonectidæ		
Corixidæ	Large metathoracic coxæ, overlapped by episterna; mesothoracic and metathoracic pleura distorted.	
Belostomatidæ		
Nepidæ		
Capsidæ	Coxæ of both mesothorax and metathorax entirely exposed, or nearly so	Similarity in general structure; pleura of meso- and metathorax usually rectangular in shape.
Nabidæ		
(Cimicidæ)		
Reduviidæ	True coxal cleft in metathorax; mesothoracic sternum and pleuron separated by a suture	
Phymatidæ		
Coreidæ		
Lygaeidæ		
Tingitidæ		
Pentatomidæ	Mesothoracic scutellum prolonged over abdomen.	
Scutelleridæ		
Corymelaenidæ		
Berytidæ	Pleura of mesothorax lengthened horizontally; metathoracic epimeron broadly joined to postscutellum	
Gerridæ		
Emesidæ		

It will be seen that these results are not entirely in harmony with the conclusions of certain writers (Osborn, 1896; Kirkaldy, 1908, 1909; Handlirsch, 1906–'08; Reuter, 1910), concerning the phylogeny of the Hemiptera. This, of course, is to be expected, since the grouping above is based entirely on the morphology of the thorax. Handlirsch, 1906–'08, places the Aleyrodidæ near the Fulgoridæ, and though superficially the two families do not seem related, the thoracic sclerites support this grouping. The arrangement of other Homopterous families followed by writers on phylogeny is not generally borne out by the morphology of the thorax.

The Notonectidæ, Corixidæ, Belostomatidæ and Nepidæ are placed together by Osborn, 1896, Handlirsch, 1906–'08, and Reuter, 1910, but Kirkaldy, 1908, 1909, separates the Nepidæ from the others. Both Handlirsch, 1906–'08, and Reuter, 1910, place the Capsidæ, Cimicidæ and Nabidæ fairly near each other, and this arrangement agrees with their thoracic structure. The close connection of the Reduviidæ and Phymatidæ is shown by Kirkaldy, 1908, 1909, Handlirsch, 1906–'08, and Reuter, 1910. The Pentatomidæ, Scutelleridæ and Corymelænidæ are usually placed together by writers on phylogeny.

It will thus be seen that relationships shown by the thoracic sclerites are supported in part by the conclusions of writers on phylogeny, especially Handlirsch and Reuter. In the relationships of the Homopterous families, of the Coreidæ, Lygæidæ and Tingitidæ, and of the Berytidæ, Gerridæ and Emesidæ the results obtained in this study do not agree with those of the writers mentioned. More extensive and thorough study of other morphological features as well as of the thorax will be necessary to show the true relationships of these groups.

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EXPLANATION OF PLATES.

(NOTE: All are lateral views unless otherwise indicated).

PLATE XX.

Fig. 1. *Cicada tibicen* (Cicadidæ). Mesonotum and wing articulation. Dorsal view.
Fig. 2. Same. Pro-, meso- and metathorax. Ventral view.
Fig. 3. Same. Prothorax.
Fig. 4. Same. Mesothorax. (A combination of conditions in *C. tibicen* and in *Cryptotympana epithesia*).
Fig. 5. Same. Metathorax.
Fig. 6. *Aphrophora* sp. (Cercopidæ). Metathoracic pleuron and sternum.

PLATE XXI.

Fig. 7. *Draeculacephala* sp. (Jassidæ). Mesothorax.
Fig. 8. *Ormenis* sp. (Fulgoridæ). Metathoracic pleuron and sternum.
Fig. 9. *Fulgora* sp. (Fulgoridæ). Metathorax.
Fig. 10. *Apsylla cistella* (Psyllidæ). Pro-, meso- and metathorax. From CRAWFORD, 1914.
Fig. 11. *Arytaina robusta* (Psyllidæ). Pro-, meso- and metathorax. From CRAWFORD, 1914.
Fig. 12. *Pemphigus acerifolia* (Aphididæ). Meso- and metathorax. See footnote page 234.
Fig. 13. *Aleyrodes vaporariorum*. (Aleyrodidæ). Metathoracic pleuron and coxa.

PLATE XXII.

Fig. 14. *Emesa* sp. (Emesidæ). Meso- and metathorax.
Fig. 15. *Notonecta* sp. (Notonectidæ). Mesothorax.
Fig. 16. Same. Metathorax.
Fig. 17. *Ranatra* sp. (Nepidæ). Mesothorax.
Fig. 18. *Belostoma americana* (Belostomatidæ). Mesothorax.
Fig. 19. *Corixa* sp. (Corixidæ). Meso- and metathorax.
Fig. 20. *Belostoma americana* (Belostomatidæ). Metathorax.
Fig. 21. *Gerris* sp. (Gerridæ). Meso- and metathorax.

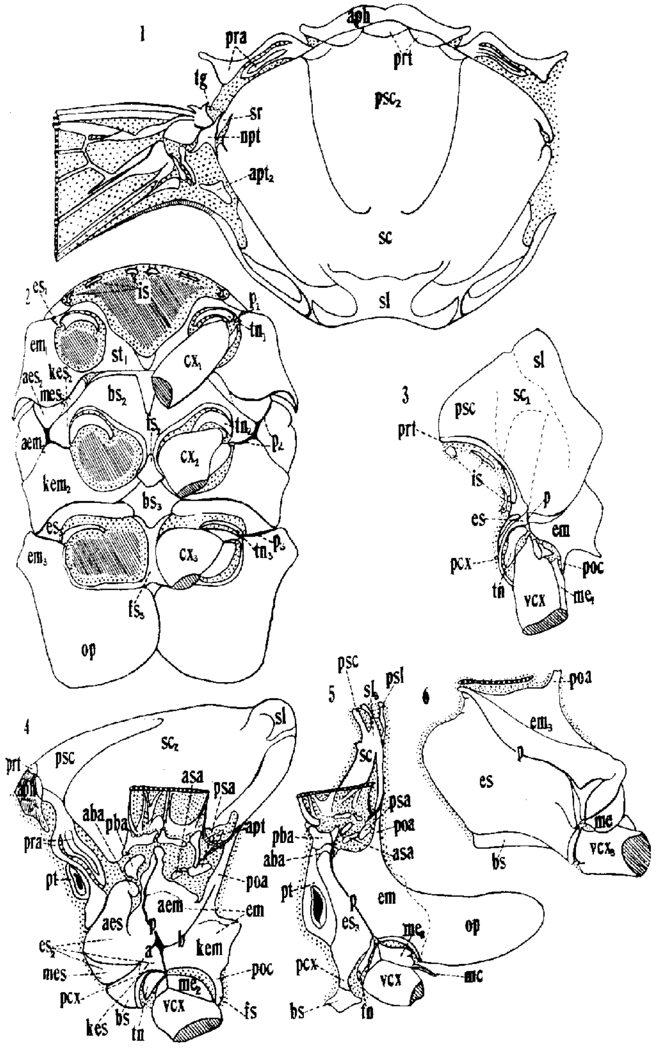
PLATE XXIII.

Fig. 22. *Neides* sp. (Berytidæ). Meso- and metathorax.
Fig. 23. *Anasa tristis* (Coreidæ). Meso- and metathorax.
Fig. 24. *Coriscus* sp. (Nabidæ). Meso- and metathorax.
Fig. 25. *Thyreocoris* sp. (Thyreocoridæ). Meso- and metathorax.

ABBREVIATIONS USED IN THE PLATES.

a, suture dividing episternum.
aba, anterior basalare.
aem, anepimeron.
aes, anepisternum.
aph, anterior phragma.
apt, adanal pterale.
asa, anterior subalare.
b, suture dividing epimeron.
bs, basisternite.
c, coxal cleft.
ce, cenchrus.
cx, coxa.
em, epimeron.
es, episternum.
fs, furcasternite.
hyp, hypopteron.
is, intersegmentalia.
it, intertergite
kem, katepimeron.
kes, katepisternum.
me, meracanthus.
me, meron.
mes, median portion of episternum.
n, notum.
npt, notopterale.
op, operculum.
p, pleural suture.
pba, posterior basalare.
pcx, precoxale.
poa, postalare.
poc, postcoxale.
pra, prealare.
prt, pretergite.
psa, posterior subalare.
psc, prescutum.
psl, postscutellum.
pt, peritreme, surrounding spiracle.
sa, subalare.
sc, scutum.
sg, opening of scent glands.
sl, scutellum.
sp, spiracle.
sr, supraalare or suralare.
ssl, scuto-scutellum (prt—psc—sc—sl).
tg, tegula.
tn, trochantin.
tr, trochanter.
vcx, veracoxa.
x, coxal articulation. (Location so indicated when concealed).

The subscripts 1, 2 and 3 indicate respectively the pro-, meso- and metathorax.


1
pra
tg
aph
prt
psc$_2$
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es$_1$
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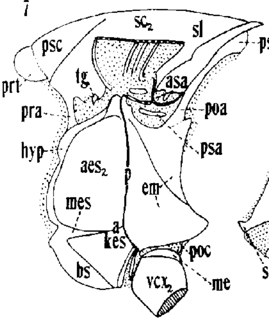

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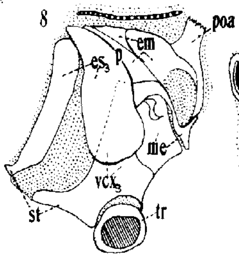

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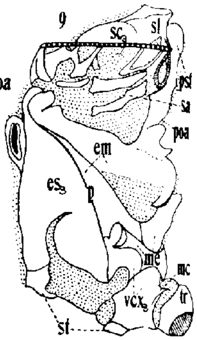

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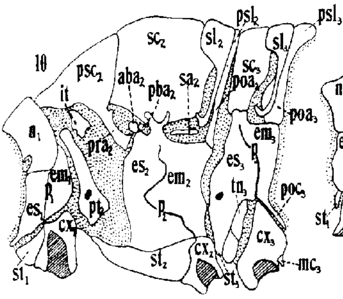

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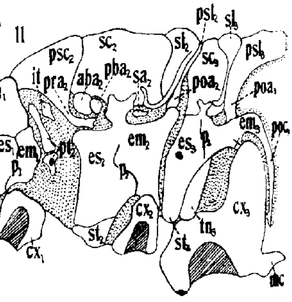

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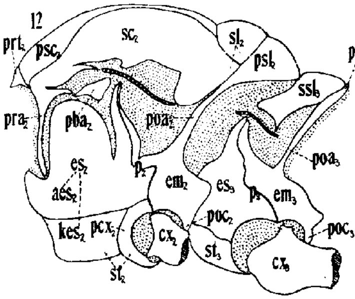

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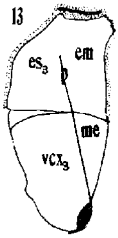

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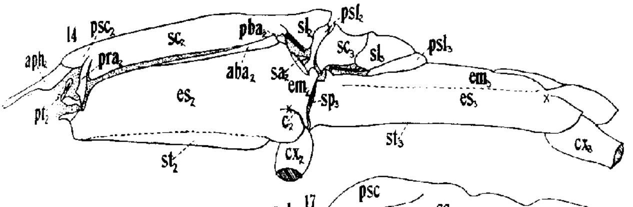

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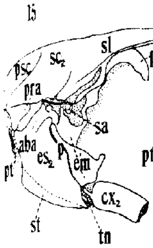

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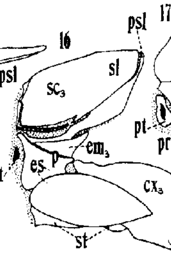

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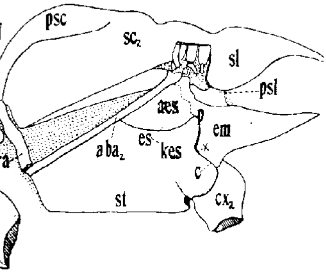

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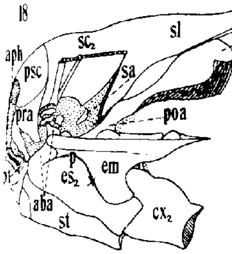

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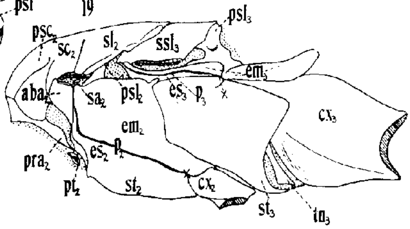

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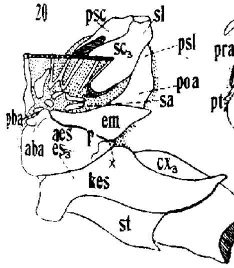

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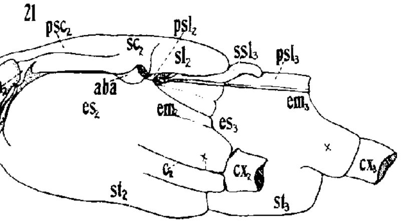

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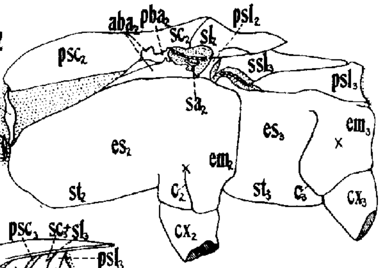

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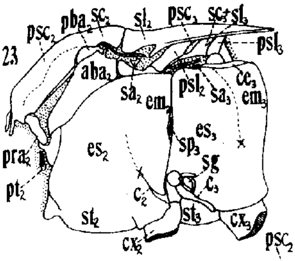

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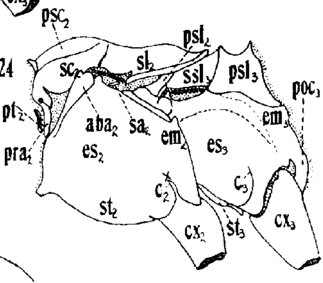

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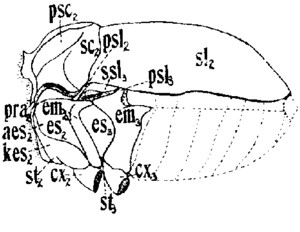

L. W. Taylor

THE ALYDINÆ OF THE UNITED STATES.

By S. B. Fracker, Madison, Wisconsin.

The family Coreidæ consists of five subfamilies, two of which, the Merocorinæ and Pseudophlœinæ, are very small. The larger divisions, often ranked as families themselves, are: Corizinæ, characterized by a mesal constriction of the fourth dorsal abdominal segment and the obsolescence of the scent-gland orifices; Alydinæ, distinguished by the wide head and unusually small bucculæ; and Coreinæ, which, together with the smaller groups named above, includes the rather diverse remaining members of the family.

The Alydinæ form a compact and easily recognizable group found in all parts of the world and include several cosmopolitan genera. Those occurring in the United States all possess a head at least three-fourths as wide as the pronotum and all except the last two genera have well developed and conspicuous scent gland orifices in front of the posterior coxæ. The bucculæ are short, not surpassing the insertion of the antennæ and the scutellum is narrower than the intraocular part of the head.

In this paper eleven genera, nineteen species and seven varieties are recognized, of which one species and three varieties are new. Material was available in all except three subtropical species (numbers 3, 4 and 8) each of which has been reported from the United States only once. The discussions of these three are based on the descriptions.

Eight of the species found in the United States, and six of the genera, are subtropical, and are confined to the southern tier of States. Four are probably limited to the Rocky Mountains and Pacific coast, and three almost entirely to the States north of the Ohio River. The remaining four have been collected in nearly every part of the United States. *Protenor belfragei*, *Megalotomus 5-spinosus*, *Alydus eurinus*, and *A. conspersus* are among the most common Heteroptera of the temperate zone.

No members of the subfamily are known to be of economic importance. The common species are found in meadows or about flowers and along roadsides. So far as observed, they are single brooded, the adults appearing in July and August and, in some species, hibernating.

In considering the distribution the published papers are indicated by numerals, and the available collections by letters used in the same way as follows: the collection of Dr. E. D. Ball, ^{b}; that of the Milwaukee public museum, ^{m}; that of Prof. W. S. Marshall. University of Wisconsin, ^{u}; that of the Wisconsin Agricultural Experiment Station, ^{a}; of Mr. Wm. J. Gerhard, of Chicago, ^{g}; and of the State Entomologist's office, including the author's collections, ^{s}. These letters thus indicate for each species the place of collection and the present ownership of the material with which the author has been working. The state names printed in *Italics* are now added to the distribution as given by Van Duzee (1917), and localities are credited to his catalogue when the present writer could find no other published records for them.

The writer is indebted to Mr. Wm. J. Gerhard, Curator of Insects in the Field Museum, Chicago; to Mr. T. E. B. Pope, Curator of Insects in the Milwaukee Museum; to Prof. H. F. Wilson of the Agricultural Experiment Station; and to Prof. W. S. Marshall of the University of Wisconsin, for their courtesy in allowing material in their private collections or under their charge to be freely used. Mr. H. G. Barber and Mr. E. P. Van-Duzee have also kindly loaned some valuable specimens. Special acknowledgments are due to Dr. E. D. Ball with whose library and collections most of the work reported herein was done and who has kindly aided with valuable suggestions. Many of the biological notes are on his authority, in particular those from Colorado.

KEY TO TRIBES OF ALYDINÆ.

a. Posterior femora not armed with spines; lateral plates of female hypopygium (in species examined) contiguous from base to apex, mesal plates concealed or wanting.
  b. Apical segment of rostrum twice as long as third, second longer than two apical segments together................*Micrelytrini*
  bb. Apical segment of rostrum subequal to third. second not longer than third and fourth together; body and legs greatly elongated..*Leptocorisini*

aa. Posterior femora armed beneath with a row of spines; lateral plates of female hypopygium distant, at least at base, exposing mesal plates. (except in *Stachyocnemus*)..*Alydini*

Tribe **Micrelytrini** Stal (1867).

One northern, three subtropical and several tropical species are united in this tribe. They resemble each other closely, are more elongate and slender than an *Alydus*, and present a trim appearance. In the first two genera the union of the juga above and in front of the tylus gives the head a very peculiar aspect.

KEY TO GENERA OF MICRELYTRINI.

a. Juga contiguous above apex of tylus; posterior angles of metapleura acute, more or less produced; lateral angles of pronotum and apex of scutellum unarmed.
  b. Juga, as seen from the side, split at apex and much longer than tylus; antennæ with first two segments subequal.......... *Protenor*
  bb. Juga as seen from the side, entire at apex, not longer than tylus; antennæ with second segment nearly twice as long as first. *Darmistus*
aa. Juga not contiguous at apex, never exceeding tylus.
  b. Pronotum with lateral angles each armed with spine; scutellum with spine at apex; posterior angles of metapleura more or less acute.. *Cydamus*
  bb. Pronotum with lateral angles unarmed; lateral and posterior margins of metapleura forming a right angle.......... *Esperanza*

Protenor Haglund.

Haplotype *belfragei* Haglund.

Protenor Haglund (1868); Stal (1867) 543, nom. nud., (1870) 217, (1873) 87; Distant (1881) 160.
Tetrarhinus Provancher (1872) 75, (1885) 57.

The produced juga, adjacent in front of the tylus and split vertically and horizontally, and the elongated body, separate this genus at a glance from all other Heteroptera. The following species is the only member of the genus.

1. **Protenor belfragei** Haglund.

Protenor belfragei Haglund (1868)[1]; Stal (1870) 217[2]; Uhler (1872) 402[3], (1876) 295[4]; Van Duzee (1889)[5], (1894)[6], (1905)[7], (1908)[8], (1912)[9]; Osborn (1892)[10], (1900)[11]; Gillette and Baker (1895)[12]; Montgomery (1902)[13]; Bueno (1908b)[14], (1910b)[15]; Smith (1910)[16]; Parshley (1914)[17]; Barber (1914)[18].
Tetrarhinus quebecensis Provancher (1872) 76[19], (1885) 57[20].

Description.—Color flavescent, closely and regularly punctate with piceous dots above, more sparsely punctate with pale fuscous or rufescent dots beneath; body, legs, and antennæ elongate, slender.

Head bearing a short mediodorsal groove between antenniferous tubercles; juga contiguous above, surpassing tylus, and split at tip vertically and horizontally so that head terminates in four short processes. Antennæ red, about as long as body.

Venter of abdomen pale, marked with a median black line continued between hind coxæ, and about a dozen black dots on each side. Hypopygium of male produced below into a caudomesal sharp spine directed posteriorly. Sixth ventral segment of female slightly split at tip and with a medioventral tubercle near the posterior margin.

Size 12-15 x 1.2-1.8 mm., males slightly smaller than females.

This widespread and rather common species in the northern States is rare in the habitat of the three other species of the tribe. With the exception of single references to Texas^{4} and Florida^{18} respectively, it appears to be limited to the territory north of Maryland and the Ohio River and east of the Rocky Mountains. In the north it is reported in Canada$^{5-8-19-2}$, *Maine*^{17}, *Massachusetts*^{13}, New York$^{6-7-14-15}$, New Jersey^{16}, Maryland$^{3-4}$, *Ohio*^{11}, Michigan$^{3-4}$, Wisconsin^{4-5-m}, Illinois^{4-}, *Iowa*$^{10-b}$, Colorado^{3-4-12}. The available collections show that it has been found in all parts of Wisconsin including the northern tier of counties.

The immature feed on sedges, and the adults are especially common in low meadows after the first of August and until frost, probably hibernating.

Darmistus Stal.

Haplotype ***subvittatus*** Stal.

Darmistus Stal (1859a) 469, (1867) 543, (1870) 217, (1873) 88; Distant (1881) 160.

One comparatively uncommon species from the southwestern states and Mexico constitutes this genus. The body, legs and antennæ are not as elongate as in ***Protenor*** and the shape of the juga is entirely different.

2. **Darmistus subvittatus** Stal.

Darmistus subvittatus Stal (1859a) 469^{1}, (1870) 217; Distant (1881) 160^{2}; Gillette and Baker (1895)^{3}; Snow (1906a)^{4}; Van Duzee (1914)^{5}.

Description.—Flavescent, more or less suffused with dark fuscous above, deeply and regularly punctate, black punctures arranged in a pair of dorsal and a pair of lateral vittæ on head and pronotum, the lateral continued on basal segments of antennæ. Antennæ with second and fourth segments subequal, each nearly twice as long as first. Sixth ventral segment of female entire at apex.

Size 10–11 x 1.5–1.7 mm.

This low-ground western species was described from Mexico and has been collected in Colorado^{3-b}, Brownsville, Texas^{4}, California^{5} and *New Mexico*^{b}. As the mature insects are found in Colorado in late August and September and again from March to June, they must hibernate as adults. The young reach maturity during August, breeding on Spartina and probably other low ground grasses.

Cydamus Stal.

Haplotype *adspersipes* Stal.

Cydamus Stal (1860) 33, (1867) 542, (1870) 216, (1873) 88; Distant (1881) 159.

The only member of this South American genus found north of Mexico is the species listed below. In form and general appearance there is a close resemblance to *Darmistus*, although the antennal lengths indicate a similarity to *Protenor*. The armed scutellum distinguishes from all other Alydinæ.

3. **Cydamus borealis** Distant.

Cydamus borealis Distant (1881) 159; Snow (1906a) 151.

Description.—Pale ochraceous, punctured with fuscous, dark punctures in longitudinal rows. Antennæ with first and fourth segments subequal in length, each as long as second and third together. Pronotum with a slender spine at each lateral angle and scutellum with an acute spine at apex.
Size 8–9 x 1.5 mm.

Snow has reported the collection of this Central American form in Texas. No material is at hand.

Esperanza Barber.

Haplotype *texana* Barber.

Esperanza Barber (1906) 269.
Cydamus subgenus *Esperanza*, Bergroth (1913).

A genus erected for *E. texana* on the basis of the following characters: Juga not attaining the tip of the broad tylus; rostrum as in other Micrelytrini; pronotal angles rounded, unarmed; posterior angles of metapleura not acute, but forming a right angle as in *Alydus;* femora unarmed.

4. **Esperanza texana** Barber.

Esperanza texana Barber (1906) 270.

Description.—Head mottled with fuscous; antennæ yellow, first segment short, spotted with fuscous, second and third subequal, longer than first and more faintly marked, fourth fuscous except at base and apex; rostrum with first segment thickened, yellow, spotted. Pronotum with mediodorsal raised smooth line. Membrane fuscous. Legs long and slender, yellow, spotted with fuscous.

This description is an abstract of Barber's, as the species, based on one male from Brownsville, Texas, has not been seen by the writer.

Tribe **Leptocorisini** Stal (1872).

Gerrida Stal (1867) 543, (in error), (1870) 217.
Leptocorisaria Stal (1872) 54, (1873) 85.
Leptocorisiini Van Duzee (1917).

Only one subtropical species represents this large, cosmopolitan tribe in the United States and but two genera are known in the western hemisphere. The remainder are Asiatic and African. The comparatively long third rostral segment and the unusually small size of the head for Alydinæ are the diagnostic characters of the group.

Leptocorisa Latreille.

Orthotype *varicornis* Fabricius.

Leptocorisa Latrielle (1829) 197; Stal (1873) 86, 87; Distant (1881) 161; and many other authors.
Gerris Fabricius (1803, not 1794); Stal (1865) 87, (1867) 543, (1868) 66, (1870) 217.
Myodocha Latreille (1807) 126, nom. nud.; et al. auct.
Myodochus Leach (1815) (1832) (not *Myodocha* Latreille (1810), a valid name in Lygaeidæ); Burmeister (1835) 325; Herrich-Schaeffer (1848) 94.
Leptocorise Latreille (1825) 421, not Latin.
Leptocorixa Berthold (1827) 418, nom. nud.; et al. auct.
Stenocoris Burmeister (1838) 1010; Herrich-Schaeffer (1853); Stal (1873) 87, as subgenus.
Leptocoris Westwood (1840) 483, in error.
Rhabdocoris Kolenati (1845) 67; Stal (1873) 86, as subgenus.
Erbula Stal (1873) 86, as subgenus.

Leptocorisa, as indicated by the many references* and synonyms, is a widespread genus with species in all parts of the world. Three of them belong to the western hemisphere, and one has been collected in the United States. The long juga, which exceed the tylus separate it from the neotropical *Lyrnessus*.

5. **Leptocorisa tipuloides** De Geer.

Cimex tipuloides De Geer (1773) 354; Goeze (1778); Retzius (1783); Gmelin (1788).
Myodocha tipuloides Latreille (1807); Lamarck (1816); Laporte (1832).
Myodochus tipuloides Olivier (1811); Burmeister (1835).
Leptocorisa tipuloides Brulle (1835); Amyot et Serville (1843); Dallas (1852) 84; Guerin (1857) 391; Mayr (1866) 113; Stal (1870) 218, (1873) 87; Uhler (1876) 294[1]; Distant (1881) 162, (1901) 331; Van Duzee (1909)[2]; Barber (1914)[3].
Leptocorisa crudelis Westwood (1842) 18.

Description.—Color pale flavescent, marked with olivaceous and rufescent. Head much shorter than pronotum, juga united to tip above tylus, which they slightly surpass. Antennæ nearly as long as body, reddish except dark apices of second and third segments. Rostrum with second segment subequal to two apical segments together; third about as long as fourth, which is black at tip.

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* A much longer list of references is given by Van Duzee (1917); the ones omitted above are European papers in which American species are not especially considered and in which the terms *Leptocorisa* and *Myodocha* are used. The history of the genus name is given by Van Duzee in Can. Ent. **46**:378, 379. 1914.

Pronotum with lateral angles rounded, unarmed. Posterior angles of metapleura acutely produced. Posterior femora reaching only half way to tip of abdomen, pale at base, rufescent at apex.

Venter pale, immaculate, darker toward apex. Sixth ventral segment of female entire, produced posteriorly into a large flat mesal lobe. Male with the hypopygium truncate unarmed at tip, completely covering the genitalia except above.

This Central and South American species has been recorded from Texas[1] and Florida[2-3]. It is the only member of subgenus *Stenocoris* Burmeister and may be distinguished from the other species from neighboring territory by the rufescent tips of the femora and the produced, entire, sixth ventral segment of the female. The body and legs are more elongate than those of any other Coreid.

Tribe **Alydini** Stal (1867).

With one exception all the common North American members of the Alydinæ belong to this tribe and nearly every species is widely distributed in the northern states. Owing to great uniformity in appearance among the fifteen nearctic species of the group, more or less confusion has existed in their determination in the past, and the distribution of some species is therefore in doubt.

KEY TO GENERA OF ALYDINI.

a. Posterior tibiæ strongly curved and produced into a distinct tooth near the apex; lateral angles of pronotum acute, armed with a spine; openings of ventral scent glands distinct, with long sulci.................... *Hyalymenus*

aa. Posterior tibiæ straight, not produced into a tooth at apex (except obsoletely in *Burtinus*).

  b. Openings of scent glands distinct, continued laterad as a sulcus with a callous margin; antennæ with first segment surpassing apex of head, fourth subequal to second and third segments together.

    c. Antennæ with first segment longer than second; sixth ventral segment of female split on the medioventral line.

      d. Posterior femora without tooth near base, tibiæ unarmed; posterior metatarsus twice as long as two apical segments together...... *Megalotomus*

      dd. Posterior femora with an obtuse tooth near base; apex of posterior tibiæ armed with a small acute tooth; posterior metatarsus about one and one-half times as long as two apical segments together...................... *Burtinus*

    cc. Antennæ with first segment shorter than second; sixth ventral segment of female entire.................. *Alydus*

  bb. Openings of scent glands obscure or obsolescent, without a callous-margined sulcus; antennæ with first segment short, not surpassing apex of head, fourth segment much shorter than second and third together.

    c. Posterior tibiæ unarmed; posterior margin of pronotum armed with an obsolete tooth or none............. *Tollius*

    cc. Posterior tibiæ armed with two rows of strong spines; posterior margin of pronotum with a mesal tooth. *Stachyocnemus*

Hyalymenus Amyot et Serville.

Logotype ***dentatus*** Fabricius.

Hyalymenus Amyot et Serville (1843) 223; Dallas (1852) 467; Herrich-Schaeffer (1853) 243; Stal (1867) 542, (1870) 210, (1873) 90; Distant (1881) 156.
Tivarbus Stal (1859a) 459.
Galeottus Distant (1893) 459.

The genus *Hyalymenus* as now limited includes all American species of Alydini in which the posterior coxæ are subcontiguous and the posterior tibiæ, compressed, curved, and armed with a strong tooth at the apex. The former character separates it from *Apidaurus*, of which the species *conspersus* is to be found in Mexico and South America.

No representatives of subgenus *Hyalymenus* in which the corium is transparent like the membrane, are known north of Central America and the Antilles. Our species all belong to subgenus *Tivarbus* Stal.

KEY TO SPECIES OF HYALYMENUS.

a. Male with posterior tibiæ serrate on the anterior margin near the middle; pleura with two to three large shining flavous spots; antennæ refuscent.
  b. Humeral spines not very long, width between apices not over one and one-third times as great as width of head; posterior femora gradually darker toward tip....................... *tarsatus* Fabr.
  bb. Humeral spines very long, width between their apices over one and one-half times width of head; posterior femora flavescent, suddenly dark ferrugineous at tip................ *longispinus* Stal
aa. Male with posterior tibiæ entire; pleura without shining flavous spots; antennæ black.. *pulcher* Stal

6. **Hyalymenus tarsatus** Fabricius.

Alydus tarsatus Fabricius (1803) 250.
Alydus atratus Fabricius (1803) 257.
Alydus diversipes Westwood (1842) 19; Dallas (1852) 477.
Alydus affinis Westwood (1842) 19; Dallas (1852) 477.
Alydus obscurus Westwood (1842) 19.
Alydus sinuatus Herrich-Schaeffer (1846) 98; nec Fabricius.
Alydus recurvatus Herrich-Schaeffer (1846) 98.
Alydus pallens Dallas (1852) 476.
Tivarbus tarsatus Stal (1859) 460.
Camptopus pectoralis Stal (1860) 34.
Hyalymenus tarsatus Stal (1868) 62, (1870) 212; Uhler (1876) 291[1]; Distant (1881) 156; Barber (1906)[2]; Snow (1907)[3].
Camptopus tarsatus Walker (1871) 162.
Galeottus formicarius Distant (1893) 459.
Tivarbus diversipes Uhler (1894) 236.

Description.—Color varying from pale flavescent to dark fuscous or nigricant; thorax with a small white spot near posterior margin of sides of pronotum and two or three large lateral white spots on the pleura near coxæ; abdomen with a row of medioventral white spots.

Abdomen depressed, third to sixth segments in the male each armed with a lateral spine, those of fourth and sixth longer than others. Male with the posterior femora armed at middle with a prominent spine and near tip with a serrate and dentate ridge; posterior tibiæ expanded, crenulate on the anterior margin at the curve. Female with the posterior femora armed with four large spines and two small teeth: posterior tibiæ less expanded, not crenulate.

Size 14–17 x 2.5–3 mm.

This variable tropical species is well known from Mexico to Brazil and has been captured in Texas[2], Arizona[3], and California.[1]

7. **Hyalymenus longispinus** Stal.

Hyalymenus longispinus Stal (1870) 213; Banks (1910)[1]; Barber (1914)[2].
Alydus (Camptopus) sinuatus Guerin (1857) 390, 391: (nec H. S., nec Fabr.)

Stal introduces *longispinus* as a new name for the Cuban species which Guerin identified and described as "*sinuatus* H. S.," with the only added information that it differs from *tarsatus* in the fact that the spines of the lateral angles of the pronotum are twice as long and directed more nearly dorsad. The characters given in the key are taken from a female kindly loaned by Mr. H. G. Barber, who records the species from Florida.[1-2] It is slightly smaller than *H. tarsatus*.

8. **Hyalymenus pulcher** Stal.

Alydus pulcher Stal (1854) 235.
Hyalymenus pulcher Stal (1870) 211; Distant (1881) 156, (1893) 372; Banks (1910)[1].

Banks lists this Central American species as occurring in Texas.[1] It differs from *H. tarsatus* in the black color of the antennæ and in the absence of the pleural white spots. The anterior margin of the posterior tibiæ of the male is entire and the posterior femora are provided with a series of small teeth throughout their length. Distant's statement that it can be distinguished from "all varieties of *H. tarsatus* by the marginal ventral spines" is apparently incorrect, as this is a secondary sexual character in both species. The armature of the femora is distinctive, however, and the tibiæ and apices of the posterior femora are nearly always black. Size 17 x 3.5 mm.

Megalotomus Fieber.

Logotype *limbatus* Herrich-Schaeffer = *junceus* Scopoli.

Megalotomus Fieber (1861) 58, 226; Stal (1872) 51, (1873) 90, 92; Montandon (1893) 50.
Alydus Stal (1867) 542; (1870) 214, (in part).
Iluphus Mulsant and Rey (1870) 158, (a palearctic subgenus of *Megalotomus*.

The lateral angles of the pronotum are more acute and the body and legs are more elongated and slender in this cosmopolitan genus than in *Alydus*, there being a close resemblance in many respects to *Burtinus*. Only one species occurs in the United States, although another, somewhat smaller one (*pallescens*) is found in the West Indies.

9. **Megalotomus quinquespinosus** Say.

Lygaeus quinquespinosus Say (1825) 323[1]; [(1859) 247[2]].
Alydus cruentus Herrich-Schaeffer (1848) 100[2]; Dallas (1852) 477.
Alydus quinquespinosus Uhler (1861) 23, (1875) 832[3].
Alydus (*Megalotomus*) *quinquespinosus* Stal (1870) 214[4].
Megalotomus (or *Alydus*) *quinquespinosus* Uhler (1876) 294[5], (1877a) 406[6], (1878) 383[7]; Provancher (1885) 56[8]; Osborn (1892)[9], (1904)[10]; Montandon (1893)[11]; Van Duzee (1894)[12]; Gillette and Baker (1895)[13]; Snow (1904)[14], (1906b); Crevecoeur (1905)[15]; Bueno (1905)[16], (1908)[17], (1913a)[18]; Bueno and Brimley (1907)[19]; Van Duzee (1908)[20], (1917)[21]; Bueno and Englehardt (1910)[22]; Smith (1910)[23]; Parshley (1914)[24].

Description.- Color dusky flavescent to rufous. Head black beneath and with a transverse semilunar black spot above; sternum of thoracic and sometimes basal abdominal segments black. Antennæ with first three segments flavescent, sometimes darker at apex, subequal in length, fourth segment much longer and with apical two-thirds fuscous.

Pronotum with lateral angles acute, and with a transverse, elongate concavity along posterior margin of the disc. Legs pale flavous, except apical half of posterior femora which is red; the latter armed with five or six spines and surpassing apex of abdomen.

Claspers of male with a large tooth-like mesal expansion near base and a long attenuated apex. Sixth ventral of female split at tip, lateral plates of hypopygium widely separated at base, convergent, broadly rounded at apex, and with mesal margins entire.

This is one of the most widely distributed Coreidæ of the northern states and appears in nearly every faunal list of Heteroptera in the temperate zone. In addition to Montandon's record of its occurrence in Florida[11], which has not been confirmed by later collectors, it has been found in Canada[8-11-20], *Maine*[24], Massachusetts[11], New York [11-12-16-17], New Jersey[16-23], Pennsylvania[7], North Carolina[18-19-22], *Ohio*[10], Illinois[4-8], Wisconsin[11-8-m-u], *Iowa*[9-b], *Kansas*[15], Colorado[5-13-b], Utah[6], *Arizona*[14], California[3], Washington[21], and Vancouver Island[21]. Collected in Wisconsin in Milwaukee[m], Dane[8-a-m-u], Sauk[u], Vernon[m], Pierce[m], Polk[8], and St. Croix[m] counties, but not so common as *Protenor belfragei* and *Alydus conspersus* and not extending so far north. After the first of August the adults may be found along the edges of woods where they are active flyers. The nymphs feed on *Oxytropis* in Colorado, according to Dr. Ball, and probably on Lupine, reaching maturity in July.

Burtinus Stal.

Haplotype *notatipennis* Stal.

Burtinus Stal (1859a) 458, (1873) 90.
Alydus Stal (1867) 542, (1870) 214; in part.

Although closely related to the preceding genus which is typically boreal, the species of *Burtinus* are tropical in distribution and only one has been found in our fauna. The generic characters are sufficiently described in the synopsis.

10. **Burtinus notatipennis** Stal.

Burtinus notatipennis Stal (1859a) 459[1], (1862) 305; Barber (1910) 5[2], Van Duzee (1917)[4].
Alydus notatipennis Stal (1870) 211; Walker (1871) 160; Distant (1893) 373[3]; Barber (1914)[5].
Alydus (Megalotomus) femoralis Distant (1881) 158[6].
Alydus (Burtinus) femoralis Distant (1893) 373[7].
Burtinus femoralis Uhler (1894)[8].

Description.—Color varying from pale flavescent to dusky ochraceous mottled and punctured with brown, more or less marked with black on head and venter. Antennæ, rostrum, and legs similar to those of *M. 5-spinosus*, but posterior femora with apical half usually marked with fuscous, sometimes flavo-annulate, not rufescent, not attaining apex of abdomen, and usually with an obsolete little tooth near base; tibiæ armed at the apex with a small spine.

Male with lateral and mesal margins of claspers subparallel to near the obliquely truncate tip. Female with mesal plates of hypopygium armed near base with a blunt lateral tooth, which engages a notch in the mesal margin of the convergent lateral plates.

Described from Central America[1-4-6-7], Mexico[1-7], and South America[1] and collected since in Lower California[8], *Arizona*[2], *Florida*[5] and Texas[3]. The relationship with Distant's species was proposed by Uhler[8] and this position has been supported by Barber[5]. *B. femoralis* should possibly, however, be listed as a variety for it is larger and paler than the form which Stal described. No other differences have been found. The specimens at hand are from Arizona (kindly loaned by Mr. Barber) and Linares and Cuernavaca, Mexico, from the Ball collection.

Alydus Fabricius.

Orthotype *calcaratus* Linnaeus.

Alydus Fabricius (1803) 248; Stal (1859a) 458, (1867) 542, (1870) 213, (1872) 54, (1873) 90; Fieber (1861) 58, 225; Distant (1881) 157; Provancher (1885) 55; Montandon (1893); Barber (1911).*
Alyde Latreille (1825) 421.

The type genus of the Alydinæ is one of nearctic origin with two palearctic and seven nearctic species. It is a compact group of closely similar forms united by the possession of armed posterior femora, unarmed pronotum and tibiæ and well developed scent gland orifices.

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* A more complete list of early references is given by Van Duzee (1917). Only those works on which the modern conception of the genus is based are named above, all except two of those before 1860 being omitted.

The species have been described singly with only meager comparative notes, with the result that superficial instead of fundamental characters have usually been employed to distinguish them. A synopsis of the genus based on coloration and wing characters has been published by Barber (1911). Owing to numerous variations, especially in *A. eurinus* and *A. conspersus*, the present writer has been compelled to rely on genitalia for the separation of these two species and their relatives. Fortunately, this method is easy to apply as *Alydus* has the claspers of the male exposed instead of covered. They are described in the Key as seen from the caudal aspect; no dissection is necessary.

KEY TO SPECIES OF ALYDUS.

- a. Venation of the membrane simple, veins not irregular and only slightly anastomosing; claspers of male when arcuate not toothed near apex; posterior femora not with pale annulus.
  - b. Pronotum with lateral angles blunt, and sides and lateral margins not distinctly paler than the disc.
    - c. Claspers of male with caudomesal margins subparallel, caudal aspect narrow (Fig. 2); female of *pluto* with lateral plates of hypopygium terminating in a tumid finger-like process (Fig. 1); sixth ventral segment with a distinct median carina; mainly mountain species.
      - d. Antennæ with fourth segment shorter than second and third together, third subequal to second; body black, not densely pilose (genitalia, figs. 1, 2)....................*pluto* Uhl.
      - dd. Antennæ with fourth segment more than one-third longer than second and third together, third shorter than second; body variegated with fuscous, densely pilose; (♂ claspers, fig. 3)............................*tomentosus* n. sp.
    - cc. Claspers of male not with caudo-mesal margins parallel; lateral plates of female hypopygium flat, not tumid at tip, sixth ventral segment with carina short, indistinct or wanting; widely distributed species.
      - d. Claspers of male twisted, not arcuate (Fig. 5); lateral plates of female hypopygium acute at apex (Fig. 4); pronotum usually black; membrane infuscate..................*eurinus* Say
      - dd. Claspers of male arcuate, divaricate at base and convergent at tip (Fig. 8); lateral plates of female hypopygium broadly rounded at apex (Fig. 7); pronotum usually with posterior two-thirds fulvous; membrane often spotted. . *conspersus* Montd.
  - bb. Pronotum with lateral angles acute and lateral margins pale; claspers of male with lateral expansion and acuminate tip (Fig. 10); lateral plates of female hypopygium bluntly rounded, approximate at apex (Fig. 9).. ....*pilosulus* H.-S.
- aa. Venation of membrane, or at least costal third, irregular with anastomosing veins; posterior femora with pale annulus near apex; claspers of male elongate, arcuate, with an enlarged stout mesal tooth near apex (Fig. 6)...*scutellatus* Van D.

11. **Alydus pluto** Uhler.

Alydus pluto Uhler (1872) 401, 402[1], (1876) 294[2], (1877a) 406[3], (1904)[4]; Gillette and Baker (1895)[5]; Snow (1906b)[6]; Van Duzee (1916)[7], (1917)[8]; [Heideman (1902); Barber (1911)].

Description. Color piceous black throughout entire head, body and appendages except as follows: Head with fulvous brown spot between ocelli, two behind each eye, and sometimes a minute one in front of eye; antennæ castaneous on base of first three segments, fourth fuscous; pronotum rarely with obscure fuscous areas on the disc; tibiæ castaneous except at tip, metatarsi flavous at base; corium infuscate. Abdominal margins rarely spotted. Form robust, moderately hairy, rather sparsely punctate. Antennæ with second and third segments together subequal to fourth.

Claspers of the male (Fig. 2) with only their narrow subparallel posterior edges showing in a caudal view, and with slight mesal expansions, near base; unlike those of any other species, except *tomentosus*. Female with lateral plates of the hypopygium (Fig. 1) terminating in a long, finger-like tumid lobe. These genital characters separate them at a glance from the robust specimens of *eurinus* from which they are almost indistinguishable by other means.

Size, ♂, 10.5–11 x 3; ♀, 12–13 x 3 mm.

A great deal of confusion has existed in regard to this species, owing to its similarity to robust forms of *eurinus*. This is evidenced by Heidemann's reference to its "very hairy" character, Barber's indefiniteness as to its identity, and Osborn's recording it from Iowa (1892) and Ohio (1900), each time with a query "(?)." After a careful study of all accessible material in the genus, the writer is convinced that the species defined above by the peculiar genitalia is the one Uhler described. The great similarity, however, in all other respects to *A. eurinus* var. *obesus* casts a doubt on the distribution records east of the Rocky Mountains. Uhler reports its presence in Colorado[1, 2, 3–5], Idaho[1–2], Texas[2], New Mexico[4], Kansas[1, 2], and Louisiana[1, 2], while *Arizona*[6], California[7], Utah[8], Washington[8], and Vancouver Id.[8] have since been added. The only specimens at hand are from Fort Collins, Sterling, and Dutch Gorge, Colorado, (Ball collection), and Dilley, *Oregon*, (from Mr. Barber).

12. **Alydus tomentosus** n. sp.

Description.—Color black, mottled with dark brown; body and legs densely covered with long, fine, black and white setæ intermixed; form more robust than in *eurinus* and not so large as in *pluto*. Head black, marked on each side with a longitudinal flavescent ante-ocular line, slightly broken at tip of antenniferous tubercle and extending nearly to apex of jugum; also a short, pale fuscous vitta caudo-ventrad of each eye. (One specimen in addition shows a small fuscous spot behind the ocelli). Antennæ fuscous, first, second and third segments black toward apex; fourth segment more than one-third longer than two preceding together, first shorter than second, subequal to third, and attaining apex of head. Rostrum piceous, paler at incisions, first segment longest, slightly longer than second and subequal to two apical ones together; fourth one-half longer than third.

Pronotum densely punctate, black, mottled with fuscous on posterior half of the disc and on the sides, sometimes with an indication of short mediodorsal and lateral marginal fulvous lines near anterior margin. Scutellum black, flavescent at tip. Corium castaneous, mottled with flavescent; membrane infuscate. Thorax and abdomen black beneath, densely hairy, sides of thorax rugose and deeply punctate. Scent gland orifices well developed. Margins of abdomen minutely flavo-maculate. Legs with the coxæ, trochanters, and tibiæ castaneous, the latter black at tip; femora black, armed with three or four long spines. Claspers of the male with mesal margins subparallel, caudal surfaces slightly expanded laterally near tip. (Fig. 3).

Size ♂, 10 x 2.6 mm.

Holotype: ♂, from Ft. Collins, Colorado.

Paratype: ♂, from La Animas, Colorado; both in the Ball collection.

This western form might easily be mistaken for *eurinus*. The male genitalia are somewhat similar to those of *pluto*, from which, however, the species is distinguished by the length of the last antennal segment, the brownish mottling of the pronotum, the fuscous corium, the smaller size, and the dense covering of long, soft, pale hairs which give the insect a greyish cast. It is possible that Heidemann had it in mind when he stated (1902) that *A. pluto* is "very hairy." None of the specimens of *pluto* at hand are as hairy as *eurinus* and Uhler's description does not indicate such a condition, his only reference to setæ being the statements that the head is pubescent, the pronotum "a little pubescent" and with bald callosities, and venter, "pubescent at tip." The species here described is more densely hairy than any other *Alydus* and the second and third antennal segments are relatively much shorter. The types are from Colorado, where they were collected at comparatively low altitudes.

13. **Alydus eurinus** Say.

Lygæus eurinus Say (1825) 324[1], (1859) 247.
Alydus eurinus Uhler (1872) 401[2], (1875) 832[3], (1876) 293[4], (1877a) 406[5], (1878a) 504[6], (1878b) 384[7]; Distant (1881) 157; Provancher (1885) 53[8]; Van Duzee (1889)[9], (1894)[10], (1903)[11], (1908)[12], (1917)[13]; Osborn (1892)[14], (1900)[15]; Montandon (1893)[16]; Gillette and Baker (1895)[17]; Montgomery (1902)[18]; Wirtner (1904)[19]; Snow (1904)[20], (1906b)[20]; Bueno (1905)[21], (1908)[22], (1910a)[23], (1910b)[24], (1912)[25]; Bueno and Brimley (1907)[26]; Tucker (1907a) (1907b)[27]; Bueno and Engelhardt (1910)[28]; Smith (1910)[29]; Barber (1911); Parshley (1914)[30].
Alydus ater Dallas (1852) 478; Stal (1870) 213[31].
Alydus pluto Prov. (1885) 56; (?) Osborn (1892), (1894), (1900).
Coriscus vicarius Prov. (1887) 175, in error.

Description.—Head, thorax, venter, and femora piceous black, verging at times to dark castaneous and sometimes apparently griseus in pilose individuals. Flavescent spots at base of head (as in *pluto*) and along margins of abdomen. Antennæ castaneous marked at the tip of each segment with piceous; apical segment fuscous; first shorter than second or third, which together are subequal to or a little longer than fourth.

Caudal aspect of clasper of male (Fig. 5) with a tumid hemispherical area at base from which arises a propeller-shaped lobe, showing a broad caudo-mesal face; claspers approximate except along caudal margin. Female with lateral plates of hypopygium (Fig. 4) flat, acute at tip, convergent; mesal plates obliquely truncate, sixth ventral segment with carina very short, indistinct, or wanting.

The only *Alydus* reported from every section of the United States is *A. eurinus*, although in Wisconsin it is not as widespread as the following species and is rare north of Madison. Throughout its range the adults are numerous in late summer along road sides and the edges of woods on goldenrod and other fall flowers. The young have been bred on Astragulus in Colorado, appearing the middle of May.

The recorded distribution is as follows: Quebec [8-12], Ontario[8], Maine[7-30], New Hampshire[7-23], Massachusetts[7-16-18], *Connecticut*[16], New York [10-21-22-24-25], New Jersey[21-29], Pennsylvania[19], Virginia[25], North Carolina[26-28], Georgia[13], *Florida*[16], Ohio[7-15-b], *Illinois*[31-8], *Wisconsin*[31-8-m-a], *Iowa*[14-16-b], Missouri[1], *Arkansas*[1], Nebraska[2], Kansas[27-b], Texas[4], Dakota[6], *Montana*[6], Colorado[5-17], *Arizona*[8-20], Utah[13], California[13].

The characters appearing in the literature do not serve to differentiate this species from *A. pluto* on one hand and *A. conspersus* on the other. In fact it is necessary to examine the genitalia in order to distinguish them. Some of the *eurinus* of the upper Mississippi valley are densely black and very robust, closely resembling *A. pluto*. These may be known as:

13a. *Alydus eurinus* var. *obesus* n. var. (=*A. **pluto*** auct. in part). Black, punctate, moderately pilose; pronotum tumid, about 3 mm. wide; corium black or nearly so; posterior tibiæ usually black. Length 12 to 13 mm.

Holotype: ♂ from Urbana, Ill. Author's collection.
Allotype: Topotypic. Author's collection.
Paratype: ♀ from Columbus, O. Ball collection.

13b. *Alydus eurinus* var. *eurinus* Say, the typical form of the species, is marked with fulvous brown on the corium, often mottled with flavescent, the pronotum is flatter on the disc and not over 2½ or 2¾ mm. wide, and the posterior tibiæ are fulvous brown to fuscous. Length 10 to 12 mm. At the same time there is sufficient intergrading to make it certain that only one species possesses the distinctive genitalia.

14. **Alydus conspersus** Montandon.

Alydus conspersus Montandon (1893)[1]; Osborn (1894)[2], (1900)[3]; Van Duzee (1894)[4], (1908)[5]; Heideman (1902)[6]; Wirtner (1904)[7]; Bueno (1905)[8], (1910)[9]; Snow (1907)[10]; Smith (1910)[11]; Barber (1911); Parshley (1914)[12].
Alydus calcaratus Uhl. (1861); in error.
Alydus rufescens, Barber (1911); ss below.

Description.—Head and anterior third of pronotum shining black, finely punctate; pronotum with posterior two-thirds usually fulvous to castaneous, occasionally darker, rarely black. Corium varying from mottled fuscous and flavescent to nearly black. Membrane spotted (var. ***conspersus***) or infuscate (var. ***infuscatus***). Segments of antennæ varying in color and length, but fourth not exceeding second and third together by more than one-eighth of their length; abdominal margins and connexivum with pale segmental maculæ or continuous rufescent border.

Male with claspers (Fig. 8) divaricate at base, arcuate as seen from the caudal aspect, convergent at tip, leaving an oval or pyriform opening. Female with lateral plates of hypopygium (Fig. 7) with mesal margins parallel and apices broadly rounded, mesal plates apparently squarely truncate at tip.

In Wisconsin and neighboring states *A. **conspersus*** is much more common than *eurinus*. It was originally separated from the latter on the basis of the spotted membrane and greyish to castaneous posterior two-thirds of the pronotum and these characters hold for a majority of the specimens seen. The strongly arcuate male claspers, surrounding an oval opening, and the character of the lateral plates of the female hypopygium which have their mesal margins subparallel and are broadly rounded at the apex are, however, the only characters on which complete reliance may be placed.

From August 1st until late fall, the adults are found in every section of Wisconsin, including the most northern counties. They copulate in September and October, and the winter is apparently passed in the egg stage.

Three varieties of this species, differing considerably from each other in color, may be distinguished as follows:

a. Membrane pale with many fuscous dots; abdomen and margins of connexivum with flavescent maculæ.......................var. *conspersus* Mont.
aa. Membrane infuscate, not dotted.
  b. Connexivum and margin of venter, black with flavescent maculæ. var. *infuscatus* n. var.
  bb. Connexivum and margin of venter broadly rufescent, latter to beyond spiracles; rufescent band sometimes slightly broken by the encroaching black coloration...........var. *rufescens* Barber

14a. *Alydus conspersus* var. *conspersus* Montandon is the typical form and the only one which has been recognized heretofore as belonging to the species. In addition to the spotted membrane, it is characterized by fulvous pronotum (except cephalic third) and castaneous corium. The distribution is strictly boreal, including Canada^{5}, *Maine*^{12}, Massachusetts^{1}, New York$^{4-9}$, New Jersey$^{8-11}$, Pennsylvania^{7}, *Ohio*,^{3} Michigan^{1}, *Illinois*^{g}, *Indiana*^{g}, *Wisconsin*$^{s-m-a-u}$, Iowa^{1-2-b}, Dakota^{1}, Colorado^{1-4-b}, and *Arizona*^{10}. The Arizona reference may concern var. *rufescens*.

14b. *Alydus conspersus* var. *infuscatus* n. var. is the melanic form of the species, closely resembling and usually identified as *eurinus*. The pronotum and corium are fuscous, sometimes even piceous, and the membrane is dark, entirely without spots. This variety and the typical *conspersus* have been captured copulating on flowers. In the available material a large number of males belong to the variety, but few females, and all the high mountain and extreme northern specimens are of this type. The distribution may possibly be limited to the northern boundaries of the spread of the species.

Holotype: ♂, from Madison, Wisconsin. State collection.

Allotype: topotypic. State collection.

Paratypes: 2 ♂s from Dutch Gorge and Palmer Lake, Colorado, respectively. Ball collection.

14c. *Alydus conspersus* var. *rufescens* Barber (*Alydus rufescens* Barber (1911) 29, 30) has been considered a distinct species heretofore but the genitalia prove it to be a southern variety of *A. conspersus*. The head, pronotum, and corium resemble those of var. *conspersus* but the membrane is infuscate and unspotted. The venter is dull bronzy black and the margins, to beyond the spiracles, rufescent, sometimes also with rufous spots on the disc; lateral rufescent band is sometimes broken into segmental maculæ.

Described from Huachuca Mountains, Arizona. A pair of topotypes was kindly loaned the author by Mr. Barber.

15. **Alydus scutellatus** Van Duzee.

Alydus scutellatus Van Duzee (1903) 108[1], (1917)[2]; Cockerell (1910)[3]; Barber (1911)[4].

Description.—Color variegated brown and black. Head above black with mesal and lateral rufous or flavous lines and about four spots of the same color, two behind the ocelli and two between antennæ. Antennæ as in *eurinus*, fourth segment shorter than second and third together. Pronotum with anterior margin dull black and mediodorsal line depressed; posterior two-thirds, and corium, fulvous brown, spotted with black. Membrane varying from pale between veins to fuscous throughout, venation varied, but always irregular and reticulated. Venter of head and thorax black, that of abdomen black with flavescent or fuscous markings varying from a small area on the fifth ventral to the entire abdomen. Femora fuscous to piceous, posterior with a broad subapical pale annulus.

Male with claspers (Fig. 6) more elongate than in other species, armed inside near apex with an expanded triangular tooth, and curved sharply cephalo-laterad at tip. Female unknown.

Described from New Mexico[1] and reported since from Colorado[3, 4], Montana[2, 4], and British Columbia[2]. A specimen is also in the Milwaukee Museum labeled "Rauterberg coll., Dubuque, *Iowa*." It is possible that this is a boreal and alpine form which will be found along the upper Mississippi. In the Rocky Mountains it has been collected from 8000 feet up to the timber line.

The species is well marked and comparatively constant. The peculiar genitalia, annulate femora, and black scutellum cause it to be unmistakable. Cockerell's material differed from the type in the pale but spotted venter and comparatively pale membrane.

16. **Alydus pilosulus** Herrich-Schaeffer.

Alydus pilosulus H.-Sch. (1848) 101; Uhler (1876) 294[1], (1878b) 384[2]; Montandon (1893)50[3]; Montgomery (1902)[4]; Bueno (1905)[5], (1908b)[6], (1910b)[7], (1913a)[8]; Hine (1907?)[9]; Tucker (1907a)[10], (1907b)[11]; Bueno and Brimley (1907)[12]; Van Duzee (1909)[13], (1914)[14], (1917)[15]; Smith (1910)[16]; Bueno and Engelhardt (1910)[17]; Barber (1911)[18], (1914)[19]; Parshley (1914)[20].
Alydus eurinus Stal (1870) 213, nec Say.
[*Alydus vittinosus* Harris, (Cata. Ins. Mass. 1833) according to Uhler (1878) 384.]

Description.—Color varying from black marked with fuscous to pale flavescent, with a few black maculæ. Head black, with a longitudinal flavescent line on dorso-meson, a pair through eyes, and another below eyes, these lines sometimes widened until only narrow black vittæ remain between them. Disc of pronotum varying from fulvous brown to fuscous, anterior third black, except at middle; margins and sides of pronotum flavescent (except near anterior margin), covered with a dense mat of white soft setæ. Sternum black, pleura fuscous to black. Venter varying from black to rufescent.

Male with claspers (Fig. 10) parallel on mesal margin, narrow at base, suddenly expanded laterally below middle, acuminate at tip. Lateral plates of female hypopygium (Fig. 9) convergent, contiguous at tip, causing mesal plates to appear triangular in shape. Size: ♀, 11 12 x 2.2 2.5 mm.; ♂ distinctly shorter and much more slender.

Less confusion has existed in regard to the identity of this species than that of the other common members of the genus as its characteristics are marked. The pronotum with its acute angles and pale margins and sides, as well as the unusual form of the genitalia are distinctive.

The distribution extends from Maine and Florida to Kansas and Texas with a single California record. The list of States is as follows: *Maine*^{20}, Massachusetts^{2-3-4}, New York^{5-6-7}, New Jersey$^{7-8}$, Pennsylvania^{15-g}, Delaware^{15}, Maryland^{1}, *Virginia*^{17}, North Carolina$^{8-12}$, Florida$^{3-13-19}$, *Indiana*^{g}, Illinois^{1-g}, *Wisconsin*^{m}, *Iowa*^{b}, *Missouri*$^{3-m}$, *Nebraska*^{m}, Kansas$^{10-11-b}$, *Louisiana*^{9}, Texas[illegible], Oklahoma$^{1-15}$, California^{14}.

Tollius Stal.

Haplotype *curtulus* Stal.

Tollius Stal (1870) 213 (as subgenus), (1873) 89 (as genus).

Although closely similar in appearance, the structural differences between *Alydus* and *Tollius* are marked. In the latter the scent gland orifices are obsolescent, the first antennal segment does not attain the apex of the head, the posterior femora surpass the tip of the abdomen and the claspers of the male are flat and approximate. Two species have been described.

KEY TO THE SPECIES OF TOLLIUS.

a. Claspers of male elongate, nearly four times as long as wide, gradually twisted near truncate apex; corium with lateral margin and often entire disc dotted with fuscous, apical margin not paler; median line of pronotum and scutellum obscure, at least posteriorly..........*curtulus* Stal

aa. Claspers of male short, not over three times as long as wide, suddenly obliquely truncate, acute at apex; corium with lateral half pale, immaculate, apical margin conspicuously so, unspotted; median pale line of pronotum and scutellum conspicuous; lateral margins of pronotum pale. *setosus* Van D.

17. **Tollius curtulus** Stal.

Alydus curtulus Stal (1859b) 234[1].
Alydus (*Tollius*) *curtulus* Stal (1870) 213.
Tollius curtulus Uhler (1876) 294[2], (1894) 236[3]; Gillette and Baker (1895)[4]; Barber (1911)[5]; Van Duzee (1916)[6], (1917)[7].

Description.—Color varying from grayish testaceous to fuscous; pubescent. Head grey above, marked with pale longitudinal stripes through eyes, beneath eyes and obscurely along dorso-meson; ventral surface black. Antennæ pale, first and fourth segments darker.

Pronotum griseous, disc marked with a pair of fuscous, slightly divergent vittæ, more obscure than in *setosus*. Scutellum with median line obscure. Corium always marked along costal margin with fuscous dots, which sometimes cover entire surface. Femora mottled, sometimes flavo-annulate.

Claspers of male (Fig. 11) slender, one-fourth as wide as long, with basal half flattened, apical half gradually twisted; apex subtruncate, especially as seen from the side; caudo-lateral portion of pygofers tumid, distinctly marked off from the ventral surface of the segment by a deep notch ventrad of their apex. Female with lateral plates of hypopygium contiguous at tip; mesal plates elongate, triangular, resembling those of *Alydus pilosulus*.

Length, 9.5 to 11 mm.; width 2.2 to 2.7 mm.

The widespread distribution of this comparatively uncommon insect has not been appreciated until recently. It is now known from New York[5], *Illinois*[m], Colorado[4], Utah, *Oregon*, California[1, 2–6], and Lower California[3]. The Illinois record is from a Chicago specimen in the Milwaukee museum and the Oregon one from ten specimens kindly loaned by Mr. H. G. Barber.

The shape of the male claspers at the apex, and of the pygofers are distinctive, though the twisted shape of the claspers makes the truncate apex difficult to see. The color markings of the insect are not nearly as attractive as in *setosus*, the sharp contrasts of the latter being wholly wanting. Twenty-six specimens from New York, Illinois, Colorado, Oregon and California have been examined by the writer and the description is based on them.

18. **Tollius setosus** Van Duzee.

Alydus setosus Van Duzee (1906)[1]; Snow (1907)[2]; Barber (1911)[3]; Bueno (1913);
Tollius setosus Van Duzee (1914)[5]; (1917)[6].

Description.—Color flavescent to castaneous, marked attractively with fuscous. Dorso-mesal pale line continuous from tylus to tip of scutellum, conspicuous. Ventral surface of head black, often narrowly. Divergent vittæ of pronotum conspicuous. Corium with the [illegible] area much darker than the costal and apical margins which are unspotted. Femora various in color.

Claspers of male (Fig. 12) short, flat, quadrangular, suddenly obliquely truncate at tip, dorso-lateral apex acute; caudo-lateral portion of pygofers scarcely tumid, apex rectangular, not distinctly marked off from ventro-caudal margin of segment by a notch. Female with lateral plates of hypopygium slightly wider at base than in *curtulus*.

Size 10 x 2.4 mm.

Originally described as an *Alydus* and compared with *A. eurinus*, *Tollius setosus* has never been satisfactorily distinguished from Stal's species. The variability in coloration in each of them and their similarity in distribution has caused some confusion. The characters used above are derived from a pair collected by Mr. Van Duzee, in California, compared by him with the type, a male, and kindly loaned the author. Two other specimens are at hand, a female from Mt. View, California, in the Ball collection, and a male sent from Mr. H. G. Barber, as having been collected in Kingsbridge, N. Y. These are identical with those from Mr. Van Duzee.

The distribution of *T. setosus* includes Arizona[1 2], Utah[6], California[4–5–b] and Montana[6], in addition to the *New York* record.

Stachyocnemus Stal.

Haplotype *apicalis* Dallas.

Stachyocnemus Stal (1870) 215, (1873) 91.

Many characters make this genus the most aberrant one of the tribe. The complete obsolescence of the scent-gland orifices, the spinose posterior tibiæ. the shape of the male hypopygium which conceals the claspers, and the absence or concealment of the mesal plates of the female hypopygium are unique. The affinities are clearly with *Tollius*.

19. **Stachyocnemus apicalis** Dallas.

Alydus apicalis Dallas (1852) 479[1].
Stachyocnemus apicalis Stal (1870) 215; Uhler (1872) 402[2], (1876) 294[3], (1877b) 1325[4]; Heidemann (1902) 81[5]; Snow (1906a)[6], (1906b)[7]; Van Duzee (1909)[8]; Smith (1910)[9]; Bueno (1913a)[10]; Barber (1914)[11].

Description.—Body covered with short stiff black setæ and more or less gray pubescence. For color, see varieties below. Antennæ with first segment widened to tip, second and third slender, subequal; fourth longer and thicker than others.

Pronotum with posterior margin bearing a mesal tooth. Hemelytra variable in length, usually slightly surpassing apex of abdomen. Anterior and intermediate femora and tibiæ slender and unarmed; posterior femora thickened, attaining apex of abdomen and armed beneath with two rows of acute teeth; posterior tibiæ armed with two rows of strong spines, those of inner row longer than the others.

Size 7.5–8 x 2–2.5 mm.

Taking the two varieties together, the species is known from Florida[1–2–3–8–11], *North Carolina*[10], *District of Columbia*[5], New Jersey[5], *New York*, *Indiana*[8], *Colorado*[5–6 8], Dakota[2], *Montana*[8], Texas[2–3–6], *Arizona*[7], *New Mexico*[4] and California[3]. In the east, according to Mr. Barber, it is "well established, but rarely taken by collectors, possibly because they do not know just where to look for it — in sandy spots."

Two varieties are found in the United States, so different in appearance that they may possibly prove to be distinct species. They may be separated as follows:

a. Juga projecting cephalo-laterad from tylus so that head appears to be three-pointed; body with little or no gray pubescence, general color black, marked with dark ferrugineous; head strongly depressed; caudo-mesal tooth of pronotum minute. . . . . .var. *apicalis*

aa. Juga scarcely projecting, indistinct as seen from above; body covered with fine grey pubescence; general color gray-flavescent; head not depressed; caudo-mesal tooth of pronotum prominent. . . . . .var. *cinereus*

The typical variety (*apicalis*, Fig's 13, 13a) is piceous black, slightly marked with dark reddish brown. It is eastern in distribution, ranging from Florida, the type locality, to New York. Specimens from Florida, New Jersey and New York have been examined.

Stachyocnemus apicalis var. *cinereus* n. var. (Fig's 14, 14a) does not answer Dallas' description of the species in any particular. It is flavescent in color, covered with dense fine white pubescence, marked above with a large fuscous triangle on the pronotum. The femora and venter are mottled, yellow and brown with numerous small dots.

Holotype: male from Fort Collins, Colorado.

Allotype: from Gunnison, Colorado.

Paratypes: male from LaSalle, Colorado; female from Fort Collins, Colorado. All in the Ball collection.

In addition to the type material the writer has examined a considerable number of specimens of the latter variety from *Colorado*; Hessville, *Indiana*; and Helena, *Montana*, in the Gerhard collection, and one from the Huachuca Mountains of *Arizona* from Mr. Barber. The types were taken at comparatively low altitudes in Colorado (5000 to 7000 feet) and were found running about the surface of the ground. Dates of capture include June, July, August, and September.

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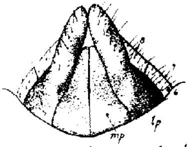
EXPLANATION OF PLATES.

PLATE XXIV.

Fig. 1. *Alydus pluto.* Caudo-ventral aspect of female genitalia. *ms*, mesal plates; *lp*, lateral plates of hypopygium; *6*, sixth abdominal segment. The lateral plates apparently represent the seventh, and the mesal plates the eighth ventral segment.
Fig. 2. *Alydus pluto.* Male genitalia, showing the caudal aspect of the claspers.
Fig. 3. *Alydus tomentosus.* Claspers of male.
Fig. 4. *Alydus eurinus.* Female hypopygium.
Fig. 5. *Alydus eurinus.* Claspers of male.
Fig. 6. *Alydus scutellatus.* Claspers of male.
Fig. 7. *Alydus conspersus.* Female hypopygium.
Fig. 8. *Alydus conspersus.* Claspers of male.
Fig. 9. *Alydus pilosulus.* Female hypopygium.
Fig. 10. *Alydus pilosulus.* Claspers of male.
Fig. 11. *Tollius curtulus.* Claspers of male. *pf*, caudo-lateral portion of pygofer.
Fig. 12. *Tollius setosus.* Claspers of male.

PLATE XXV.

Fig. 13. *Stachyocnemus apicalis* var. *apicalis.*
Fig. 14. *Stachyocnemus apicalis* var. *cinereus.*



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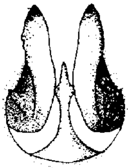
1

A. pluto



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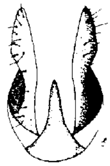

A. tomentosus
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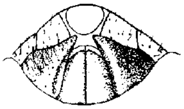

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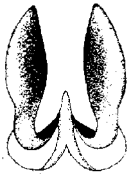

A. eurinus ♂
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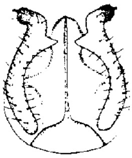

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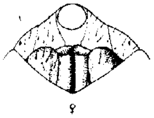
A. scutellatus



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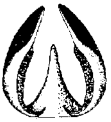
A. conspersus



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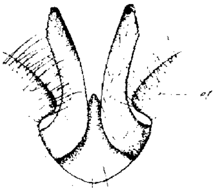

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Tollius curtulus
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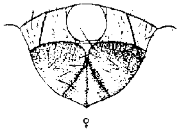

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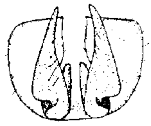

A. pilosulus ♂
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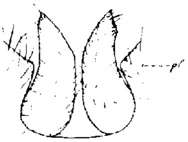
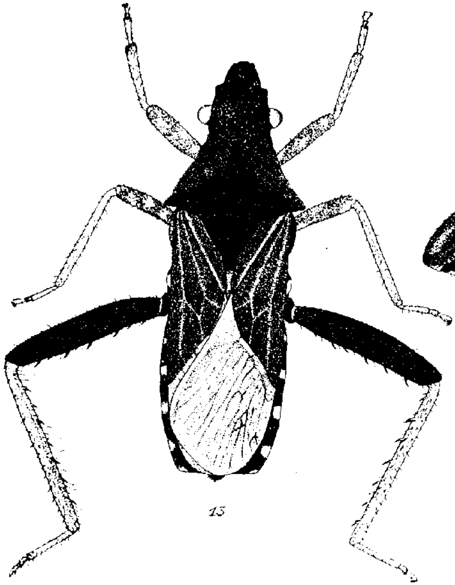
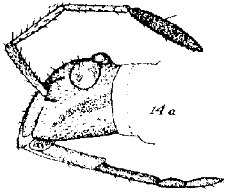
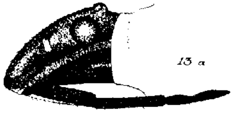


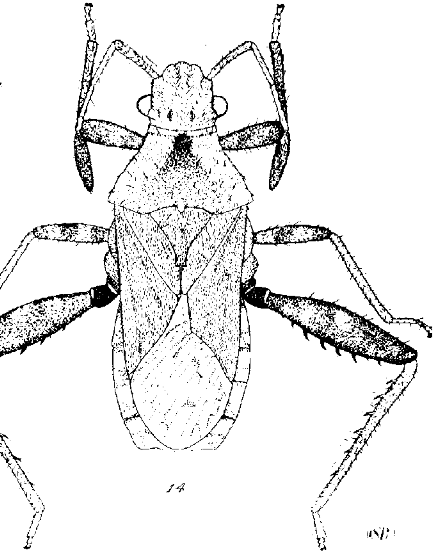
♂
Tollius setosus
12

S. B. Fracker









S. B. Fracker

THE ALIMENTARY CANAL OF THE LARVA OF ALTICA BIMARGINATA SAY (Coleoptera).*

By William Colcord Woods.

1. The gross anatomy.
2. The histological structure of the alimentary canal.
3. The Malpighian vessels.
4. The salivary glands.

I. THE GROSS ANATOMY OF THE LARVAL CANAL.

In the alimentary canal of the alder flea-beetle, *Altica bimarginata* Say, (Chrysomelidæ) as in insects generally, three primary divisions of the digestive tract are at once evident; the fore-intestine (stomodaeum), the mid-intestine (mesenteron or ventriculus), and the hind-intestine (proctodaeum). In this larva, the comparatively short alimentary canal, which is a nearly straight tube with few convolutions, is somewhat less than half again as long as the body. The writer has already published a figure showing the general structure (Woods 1916, Fig. 1).

The alder flea-beetle is entirely a plant feeder, living usually on the leaves of the alder (*Alnus incana* Moench), or more rarely on the willow (*Salix* spp.), or the balsam poplar (*Populus balsamifera* L.). Among adult insects the carnivorous species as a rule have rather short, straight intestines, whereas the phytophagous species tend to have longer and more convoluted digestive tracts. The larva of the alder flea-beetle does not really form an exception to this generalization, although at first sight it may appear to; for the alimentary canal, though short, is of considerable diameter throughout, so that what it may lack in length is made up in volume. Gastric coeca such as are developed in the Acridiidæ or in *Corydalis* are entirely wanting.

The fore-intestine is short, extending back only as far as the beginning of the second thoracic segment. Two divisions only are recognizable in it upon dissection, but histologically four regions can be distinguished, the first three appearing to constitute a single region macroscopically. These parts are first the buccal cavity, then the pharynx (the limits of which are determined by the attachment of the muscles which run from the alimentary canal to the body wall), and third, a short, narrow, muscular oesophagus which extends as far as the prothorax, where it gradually broadens out into a thin-walled distensible crop, the fourth division, the diameter of which is half as great as that of the mesenteron. A constriction, as well as a conspicuous difference in the thickness of the walls, marks externally the separation between the fore-intestine and the mid-intestine.

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* Contribution from the Entomological Laboratory of Cornell University.

The mid-intestine composes by far the largest part of the digestive tract of this species. The ventriculus runs through the body as a straight tube of nearly uniform diameter, from a point near the beginning of the mesothorax to the end of the fourth abdominal segment, where a slight constriction is apparent; from here on it is somewhat convoluted and of less diameter, extending nearly or quite to the end of the seventh abdominal segment. Correlated with this macroscopic division into the two sections, is a differentiation of the lining epithelium.

The hind-intestine, which is composed of three regions, begins in the posterior portion of the seventh abdominal segment, where it joins the mid-intestine at a sharp angle. The six Malpighian vessels arise at the point of union. Their origin and distribution has already been discussed (Woods 1916). They are divisible into two series, the first (i. e., posterior) consisting of four vessels, and the second (i. e., anterior), of two. The vessels of the second series arise as separate evaginations from the intestine at the point where the mid-intestinal epithelium passes into that of the hind-intestine. The vessels of the first series unite into a bladder, which opens directly (i. e., without a stalk or urethra) into the lumen of the ileum (first division of the hind-intestine), slightly posterior to the evagination of the tubes of the second series. After a greater or less course through the body-cavity, the vessels of the first series unite into two pairs, and to each pair is joined one of the vessels of the second series, so that two common trunks of three vessels each are formed. These trunks pass into the wall of the colon (second division), where they end blindly in irregular ramifications.

At the junction of the mid-intestine with the hind-intestine there is a sharp turn in the alimentary canal, so that, between the mesenteron which runs caudad and the ileum which runs cephalad, is formed a U-shaped bend, on the inner side of which the bladder opens. Having bent forward, the hind intestine extends as far cephalad as the posterior edge of the fifth abdominal segment, where it turns back on itself; this bend marks externally the separation between the ileum and colon. The colon, which is nearly straight, runs caudad as far as the anterior edge of the ninth abdominal segment, ventrad of the ileum. The colon passes directly into the rectum (third division), which is only one segment long. The anal opening is in the center of the anal proleg, and is shaped like an inverted Y. Macroscopically no difference is apparent between the ileum and the colon. The colon is smaller than the second division of the ventriculus; anteriorly, the colon is of the same diameter as the ileum, but it gradually increases in size posteriorly. The rectum is surrounded by powerful circular muscles, which show up clearly in a dissected specimen, and clearly differentiate it from the rest of the alimentary canal.

The structure of the different regions of the alimentary canal is discussed in the remainder of this paper. The parts are considered in order, beginning at the anterior end.

2. THE HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL.

The Fore Intestine.

THE MOUTH-PARTS AND THEIR MUSCLES.

Mouth parts. The mouth parts of the larva of the alder flea beetle consist of the typical biting pieces: a labrum, two mandibles, two maxillæ, and a labium. The writer has already published figures of these structures (Woods 1917, Fig. 19).

Cuticular invaginations. There are four cuticular invaginations in the head of this larva, one unpaired and three paired, which serve for the attachment of muscles. The unpaired cuticular invagination extends along the mid-dorsal line of the head from the caudal margin of the epicranium as far cephalad as the clypeus. Both primary and secondary cuticulæ are equally involved. The paired invaginations arise from the labrum, the mandibles and the maxillæ.

The first is a very slight cuticular invagination on each side of the labrum. Both cuticular layers take part in its formation. The mandibular tendon is a long chitinous invagination extending caudo-mesad from the posterior edge of the inner face of the mandible. It is formed almost entirely of the secondary cuticula. The maxillary tendon arises at the end of the chitinized portion of the stipes, and extends mesad in a curved line, so as to form a semi-circle. Both layers of chitin contribute equally to its formation.

Muscles. Two sets of muscle fibres are connected with the labrum. A large muscle fibre runs on each side from the labral invagination to the median dorsal invagination. Their contraction closes the labrum firmly against the mandibles. The second set consists of five or six fibres which run between the labral invaginations. Their contraction tends to pucker the labrum. There does not seem to be a set of fibres to open the labrum. All of these muscles are cephalad of the oral invagination, and of the supra-œsophageal ganglion.

The muscles connected with the mandibles occupy the greater part of the head cavity. There are two principal sets. Both are attached to the mandibular tendon; the flexor muscles extend to the median dorsal invagination, or to the body wall entad of the tendon, while the retractor muscles extend to the cuticula ectad of the tendon. The most cephalic fibres are anterior to the labral muscles, while others extend caudad as far as the œsophageal connectives. There is also a third set of mandibular muscles which are but slightly developed. They are inserted at one end on the cuticula of the outer face of the mandible, and at the other on the cuticula of the body wall at the base of the mandibles. Their contraction would serve to close the mandibles very tightly.

The maxillary muscles arise on the maxillary tendon and extend to the gula. There are about twenty fibres connected with each maxilla.

The labial muscles arise on the thickened cuticula at the distal end of the mentum, and are inserted on the gula. There are about five fibres on each side of the labium.

Attachment. The muscles are attached through the hypodermis to the secondary cuticula (or through the epithelium to the secondary intima) both here and elsewhere in the body.

The hypodermal cells through which the attachments are made become fibrillar, and their fibrils interlace with those of the muscles. (See figure 1, A). In some sections of just molted larvæ, these tendons are quite long, but usually the cells are not drawn out at all. (See figure 1, B). The basement membrane of the hypodermis or epithelium appears to be continuous with the sarcolemma of the muscles.

THE BUCCAL CAVITY.

As is to be expected, longitudinal sections show clearly that the cuticula of the body wall is directly continuous with the intima of the fore-intestine, the hypodermis with the epithelium, and the basement membrane of one with the basement membrane of the other. The primary cuticula is of about the same thickness as the primary intima, but it becomes deeply pigmented and beset with many cuticular nodules as soon as it is outside of the oral invagination. The secondary cuticula is also of about the same width as the secondary intima, and both stain pink with eosin. The intima of the buccal cavity is armed with small backward directed spines.

The epithelial cells are considerably larger than those of the hypodermis, but the transition is gradual and there is no abrupt change of type, the cells first becoming higher than the flat hypodermis, and then gradually broadening out into the cuboidal form characteristic of the pharyngeal and œsophageal epithelium.

THE PHARYNX.

In this species, the limits of the pharynx can be determined only by the attachment of the muscle fibres which run to the body wall. Dorsally there are two sets of these, one of four fibres running perpendicularly, and the other of three extending at an angle, to the body wall. Ventrally there is a single set which consists of two large fibres running nearly vertically to the body wall. These muscles are all paired. They are attached to the intima in the usual way, and their sarcolemmata appear continuous with the basement membrane.

The oral invagination is shown in figure 2. The location of the pharyngeal muscles is shown in figure 3.

The histological features of the pharynx and œsophagus are identical as regards the type of intima and epithelium, which are discussed under the latter region. In the pharynx the epithelium is simple and is not thrown into the folds so characteristic of the œsophagus, and this character helps to distinguish between the two regions.

THE ŒSOPHAGUS.

Intima. In this region the intima, which is comparatively well developed, appears, in cross sections, to be thrown into a series of strong longitudinal folds, usually six in number. The primary intima is well developed; the secondary intima is thicker, and stains with eosin. The primary intima bears sharp backward directed spines. The apparent teeth which the folds make almost close the lumen at the anterior end, but become weaker and weaker posteriorly.

Epithelium. The epithelium of the œsophagus is composed of large cuboidal cells; the cell divisions are not always clear, but this is doubtless due to the fixative, and does not represent any tendency toward a syncytium. There is a great variation in the size of the cells. The cytoplasm, which stains a violet-pink with eosin, appears almost homogeneous; it is non-granular and non-vacuolar. The nuclei are round-oval both in cross and longitudinal sections; they are comparatively small, and are densely filled with coarse deep-staining chromatin granules.

There is no indication of salivary cells in the œsophagus as were reported for *Hydrophilus* by Plateau (1874), and have since been recorded for several other insects.

Just after a molt, and throughout each instar, the epithelial cells lie close against the intima, and the above description has reference to such a condition. But several days before the insect is ready to cast its skin, a very characteristic premolting condition develops. The cells, which seem to be glandular in their nature, appear to secrete a fluid beneath the intima. They become fibrillar entad, and the spaces between the narrow cytoplasmic strands are probably filled with a secretion. As this process continues, in a characteristic section, the epithelium seems separated from the intima by a fibrillar vacuolar portion, which stains light blue with Delafield's hæmatoxylin. Toward the end of each instar the fibrillar portion constitutes the bulk of the apparent teeth which the folds of the intima make, and the epithelium does not pass out into these projections at all, as it does earlier in the instar. At all times, the true cytoplasmic area of the cells is sharply marked off from the fibrillar portion.

This fluid doubtless functions in connection with the molting of the intima of the fore-intestine, for this is of course shed at each molt, with the rest of the chitinous structures derived from the ectoderm.

The epithelium in the newly hatched larva, and after each of the two molts, lies directly against the intima. This fibrillar secretion is developed in all three of the larval instars. Eventually it also extends out more or less into the undifferentiated hypodermis of the body wall, with which the epithelium is continuous, but this premolting condition is always apparent in the alimentary canal before any of the hypodermal cells are affected. In the full grown larva, this area is apparent at least three or four days before it ceases feeding. The new intima appears on the last day before the larva enters the ground, and the secondary intima becomes apparent on the fourth day of prepupal life.

The œsophagus is shown in cross-section in figure 4; a few epithelial cells, in the typical state, in figure 5; a few epithelial cells in the premolt condition, in figure 6; and a few epithelial cells after the new intima has been formed, in figure 7.

Basement membrane. A structureless limiting membrane is clearly distinguishable in all of the sections which were examined. Neither here nor elsewhere in the canal has the writer found nuclei in the basement membrane, and he believes that it is formed by the hypodermal cells themselves, and is not of connective tissue.

Longitudinal muscles. From twenty to twenty-five longitudinal muscle fibres occur inside of the circular muscle layer. They are inserted proximally on the intima at the very beginning of the pharynx; they continue not only throughout the fore-intestine, but through the mid-intestine, and a part of the hind-intestine; distally they are inserted on the intima at the end of the ileum. In a general way, the arrangement of these muscles is like that described by Balbiani (1890) for *Cryptops*.

Circular muscles. The circular muscles are strongly developed. There is but a single layer of them. The most cephalic muscle is inserted on the intima at the very beginning of the pharynx, but they are lodged in a connective tissue envelope which is continuous throughout the whole alimentary canal as far as the rectum, and forms a complete membranous cylinder around the digestive tube. As is the case with all of the muscles of the alimentary canal of this insect (and probably of all others), they are clearly striated.

THE CROP.

Transition. The transition from the œsophagus to the crop is gradual. The lumen grows gradually wider, the epithelium becomes thinner and more stretched, and the chitinous folds become less and less pronounced as one traces the œsophagus posteriorly.

Intima. The intima is very much thinner than in the œsophagus, and while it is thrown into many minute wavy folds, the six large primary folds have disappeared entirely. Both primary and secondary intima may be recognized; they are of the same nature as the corresponding structures in the œsophagus, but are much more delicate.

Epithelium. In both cross and longitudinal sections, the cells appear as if they were stretched; their bases are long, and their altitude low, so that instead of being cuboidal, they present the aspect of long, narrow rectangles. The oval, granular nuclei stain quite deeply, but are not as chromatic as those in the pharyngeo-œsophageal epithelium. The cytoplasm is homogeneous, non-granular and non-vacuolar.

As in the rest of the fore-intestine, a fibrillar area is developed between the epithelium and the intima previous to each molt. It is much less extensive than in the pharynx and œsophagus, probably because the thin, little folded intima is shed much more easily than the thick, strongly folded intima which lines the other regions.

A cross-section through the crop is illustrated in figure 8.

Basement membrane. A well developed basement membrane is present.

Longitudinal muscles. The longitudinal muscles are represented by isolated striated fibres, which continue anteriorly into the pharyngeo-œsophageal region, and posteriorly into the ventriculus.

Circular muscles. The circular muscles are much stronger than the longitudinal fibres. They appear to be continuous with the muscles of the œsophagus anteriorly and with those of the ventriculus posteriorly, since they all lie in the same connective tissue sheath.

THE ŒSOPHAGEAL VALVE.

In typical cases among insects, such as *Pieris* or *Simulium*, the œsophageal valve is a large fold of the fore-intestine, which projects down into the mid-intestine, almost closing the aperture between them. The function assigned to it is that of preventing the regurgitation of food, due to the peristaltic movements of the intestine.

In *Altica bimarginata* there is a fold of the fore-intestine which projects slightly down into the mid-intestine, and marks the point of transition between these two regions. It is by no means large enough to close the lumen and can be of but little if any use as a means of preventing the repassing of food into the fore-intestine. However, there is a strong constriction between the crop and the ventriculus, and the opening between the two is much less than the diameter of the alimentary canal at this point, so an œsophageal valve is little needed, and this fold is probably all that is necessary. In its structure the œsophageal valve is much like the rest of the crop. Intima, epithelium and basement membrane are clearly distinguishable. The primary intima becomes very thin, but distinction between primary and secondary intima continues to the end. This condition is very similar to that described by Poyarkoff (1910) in the elm leaf beetle.

The œsophageal valve of *Altica bimarginata* is shown in figure 9.

THE TRANSITION BETWEEN THE FORE-INTESTINE AND THE MID-INTESTINE.

Intima. The intima disappears at the end of the fore-intestine.

Striated border. A striated border is developed on the inner face of the cells in place of an intima throughout the mid-intestine.

Epithelium. There is a well marked transition between the type of epithelium characteristic of the fore-intestine and that characteristic of the mid-intestine, even though there is no sudden change. The cells of the fore-intestine at the posterior face of the œsophageal valve become first cuboidal, and then narrower and more elongate, passing almost imperceptibly into the type characteristic of the mid-intestine.

The transition area is shown in figure 9.

Basement membrane. The basement membrane is continuous from the crop to the ventriculus.

Imaginal ring. There is no clearly defined imaginal ring. The cells on the extreme posterior face of the œsophageal valve are very small and close together, and probably constitute the imaginal ring of the fore-intestine. This is very comparable to the conditions described by Poyarkoff (1909, 1910) in the elm leaf beetle, where the imaginal mid-intestine is derived from the cells of the posterior face of the larval œsophageal valve, although these cells are not sharply separated off as a distinct imaginal ring in the larva. The cells are never crowded together in *Altica* so as to form an apparently several layered imaginal ring, as in the case in Cybister (Deegener 1904), where the ring lies above the œsophageal valve.

Longitudinal muscles. The longitudinal muscle fibres are continuous from the fore-intestine into the mid-intestine. With respect to the connective tissue sheath in which the circular muscles lie, they are internal in the fore-intestine, but at the point of junction between the crop and the ventriculus, each fibre divides into two or three smaller ones which penetrate this sheath, so that the longitudinal muscles lie outermost in the mid-intestine. There are about twenty of these fibres in the fore-intestine, and about forty at the anterior end of the mid-intestine.

The passage of these muscles from the crop to the ventriculus is shown in figure 10.

Circular muscles. The circular muscles of the fore-intestine and the mid-intestine appear to be continuous, since they both lie in the same connective tissue tube around the intestine, but doubtless here, as in all insects in which the conditions have been studied, embryologically they have very different origins, and are not homologous. The muscles immediately at the junction form a strong sphincter.

THE MID-INTESTINE.

THE FIRST DIVISION OF THE VENTRICULUS.

Striated border. The epithelium of the mid-intestine never supports an intima in insects, but instead is clothed with a striated border, which is very characteristic of this region. This striated border is usually considered as a vestige of a formerly ciliated condition. In this species, the striated border is always conspicuous and well developed. The striæ are close together, and are not always sharply separated from the cytoplasm interiorly.

Epithelium. The epithelium is of the columnar type, and the cells are very clearly defined. They vary greatly in size and shape; they may be almost cuboidal, or more than twice as high as wide, probably depending upon their physiological condition. In general, the more anterior cells are the higher. The nuclei are large, median, and almost round; they are quite densely filled with coarse chromatin granules, and there are from one to three larger granules, probably nucleoli. The cytoplasm is non-granular, but is usually more or less vacuolar.

The secretion is merocrine. In the resting state the cytoplasm becomes charged with vacuoles, which pass to the outer margin of the cell, beneath the striated border, where they merge into larger drops. At the time of the secretion these cytoplasmic balls pass out of the cell through the striated border, apparently pushing away the striæ on either side. In the process of being discharged, they remain more or less attenuated on the inner end, but they become spherical as soon as they are free in the lumen of the canal. They stain with eosin, and appear homogeneous.

The first division of the mid-intestine is shown in figure 11.

Replacement cells. During the pupal and prepupal period of most, if not all, insects, the epithelium of the mid-intestine breaks down completely, and a new epithelium is built up from little cells or groups of cells, which lie at the base of the ordinary epithelial cells. In *Altica bimarginata* at least, they seem to remain quiescent during larval life, but begin to proliferate actively during the prepupal period, in which the old larval epithelium breaks down, and a new epithelium is developed, apparently out of these replacement cells. They are apparent in sections through larvæ which have just hatched from the egg.

The replacement cells are more or less triangular cells, which lie at the bases of the functional cells, at irregular intervals, wedged in between two of the cells. The nucleus is large in proportion (it is almost as large as that of the active cells), and there is but relatively little cytoplasm, which is non-granular and non-vacuolar. The nuclei stain a little more deeply, and the particles of chromatin are a little coarser than is the case with the nuclei of the functional cells. Three replacement cells are shown in figure 11.

Basement membrane. A very delicate basement membrane, on which both the functional and the replacement cells rest, can be detected in well fixed preparations and is doubtless present in all cases.

Circular muscles. Striated circular muscle fibres surround the mid-intestine, lodged in a continuous sheath of connective tissue, which forms a complete tube around the canal. The fibres are branched, and often interlace.

Longitudinal muscles. The longitudinal muscle fibres lie outside the circular muscle layer. There are about forty of these fibres, which branch and interlace to some extent.

THE SECOND DIVISION OF THE VENTRICULUS.

Striated border. The striated border is not well developed in this region, but is doubtless always at least feebly developed, even when it is not apparent in sections. It is not even as sharply separated from the cytoplasm as in the preceding region.

Epithelium. The columnar epithelium is composed of cells which are comparatively much longer and more slender than those of the prececding region. On the free end the cell outlines are less even and very irregular, instead of about equal and straight. The nuclei are of about the same size, but are oval rather than round; they are median, or slightly basal if the secretion be abundant.

The second division of the ventriculus is shown in figure 12.

The secretion takes place in the same manner as before, but much more actively and abundantly. It is of quite a different chemical nature, for the cytoplasmic balls stain a light pink with eosin, and are very granular.

Replacement cells. The replacement cells are of the same type and arrangement as in the preceding region.

Basement membrane. The basement membrane is of the same character as in the preceding region.

Circular muscles. The condition of the circular muscle fibres is the same as in the preceding region.

Longitudinal muscles. The longitudinal muscle fibres are continuous with those of the preceding region. They are more numerous, as the fibres split up more or less at the point of junction between the two regions.

The musculature of the two regions of the ventriculus is shown in figure 13.

THE HIND INTESTINE.

THE TRANSITION BETWEEN THE MID-INTESTINE AND THE HIND-INTESTINE.

Striated border. The striated border stops with the end of the mid-intestinal epithelium. It is very faint and feebly developed, as is characteristic of the whole posterior portion of the second division of the ventriculus.

Intima. A chitinous intima originates with the epithelium of the hind-intestine. The primary intima is very thin, the secondary somewhat broader. Neither layer is stained by eosin nor by Delafield's hæmatoxylin.

Epithelium. There is a sharp break between the epithelium of the mid-intestine and that of the hind-intestine. The epithelial cells of the mid-intestine do not differ markedly from the normal as the transition area is approached, save that the replacement cells become very numerous, and tend to form small nests or nidi, instead of occurring singly. At the extreme end of the mid-intestine, the cells lose their columnar character, the cell divisions become very indistinct, and the replacement cells are abundant. The epithelium of the hind-intestine is clearly separated from that of the mid-intestine. The cells, at first narrow, become higher and wider, and shortly merge into an epithelium perfectly typical of the proximal division of the ileum. The cytoplasm is vacuolar and very fibrillar.

The transition area is shown in figure 14.

Pyloric valve. There is no pyloric valve.

Imaginal ring. The cells at the extreme anterior end of the hind-intestine are very small, narrow, and pressed closely together; they probably constitute the imaginal ring of the hind-intestine, although they never present a several layered appearance. This is much the same condition which Poyarkoff (1910) described for *Galerucella.*

Basement membrane. The basement membrane of one region is continuous with that of the other.

Circular muscles. The connective tissue sheet, in which the circular muscle fibres lie, is continuous from the mid-intestine into the hind-intestine, so that the circular muscles of the two regions appear to be homologous and continuous but doubtless embryological researches would show that, as is the case with insects generally, they have entirely different origins. There is a sphincter at the point of junction.

Longitudinal muscles. The longitudinal muscle fibres are continuous from the mid-intestine into the hind-intestine. As the transition area is neared, the numerous longitudinal muscles of the mid-intestine (fifty or sixty in number) come together so as to form eighteen or twenty larger fibres, which again penetrate through the connective tissue sheath of the circular muscles, so as to lie outside of them, as is the case in the fore-intestine.

This condition is illustrated in figure 15.

THE EVAGINATION OF THE SECOND SERIES OF MALPIGHIAN VESSELS.

(It seems illogical to speak of the more anterior set of Malpighian tubes as the second series, but the writer prefers this usage, because he believes that the close association of this series with the mid-intestinal epithelium is entirely secondary, and that the opening of the bladder formed by the vessels of the first series represents more nearly the primitive insertion of the tubes).

The two Malpighian vessels of the second series arise at the extreme posterior end of the ventriculus, appearing abruptly, before there is any change in the mid-intestinal epithelium. Their cells are, however, very distinct from the ventricular epithelium. They are lined by a very faint striated border. The lumen of the vessels is continuous with that of the intestine. The two vessels arise very close together. As soon as they penetrate the connective tissue layer in which the muscles are imbedded, it continues around them as a nucleated peritoneum. Their basement membrane is continuous with that of the alimentary epithelium.

The evagination of these vessels is shown in figure 16.

Their structure and relations make it perfectly clear that any connection which they have with the mid-intestine is entirely secondary. Although there may be two or three cells of the mesenteron which lie between them and the hind-intestine, their complete fusion distally with the vessels of the first series, makes it clear that they are appendages of the hind-intestine; and their present point of origin from the ventriculus is due to secondary migration.

THE PROXIMAL PORTION OF THE ILEUM.

Proximal and distal ileum. The first division of the hind-intestine, the ileum, may be divided histologically into a proximal and a distal portion. The proximal portion extends from the beginning of the hind-intestine as far as the opening of the bladder. The distal region includes all of the ileum beyond this point.

The proximal ileum corresponds to the first region of the hind-intestine, and the distal ileum to the second region, as Poyarkoff (1910) considered them in *Galerucella*.

Intima. The primary intima is very thin, but the secondary intima is fairly thick. Neither layer is stained with eosin nor Delafield's haematoxylin, but the primary layer contains brown pigment.

Epithelium. The epithelium is composed of wide, flat cells, very much smaller than those of the distal region, as are also the round chromatic nuclei, full of densely-packed coarse granules. The cytoplasm is homogeneous, and usually non-vacular. The epithelium is thrown into small, wavy, pointed folds.

Basement membrane. The basement membrane is well developed.

Longitudinal muscles. There are about twenty longitudinal muscle fibres, which lie in a continuous connective tissue sheath. Anteriorly they are continuous with the muscles of the ventriculus, and posteriorly they are inserted on the intima at the end of the distal portion of the ileum.

Circular muscles. The circular muscle fibres are well developed and lie in the connective tissue sheath outside that of the longitudinal fibres, this sheath being continuous with that of the mid-intestine. There are thus in the ileum two connective tissue sheaths around the canal outside the basement membrane of the epithelium.

FORMATION AND ATTACHMENT OF THE BLADDER.

The four Malpighian vessels (those of the first series) whose fusion at their proximal ends is to form the bladder, run closely parallel to one another between the ventriculus and the ileum, for some little distance before they unite. At the point of fusion there is at first no change in the character of the cells, and an ovoid swelling is formed without any interruption of the separate lumen of each tube. The two outer vessels (i. e., the two nearest the ileum) unite first, and their combined lumen is lined with very small epithelial cells, with a faint striated border. The other two vessels are arranged at right angles to them, with their lumina still distinct, and their cells of the usual size. Here as elsewhere the whole enlargement is invested with a basement membrane and a nucleated peritoneum distinct from the former. The cells of the two inner vessels become smaller abruptly, and in a few sections of six micra each, an uniform bladder results, with a common lumen (made up of the fused lumina of the four vessels) lined by a single layer of epithelial cells. The striated border, faint everywhere in the fusing vessels, has now disappeared and is replaced by a thin intima. In some cases the epithelium seems to consist of more than a single layer, but this is only apparent, not real, and is due to folding. The cell divisions are never clearly distinct. The nuclei of the bladder cells are of the same essential structure throughout, although they vary greatly in size, according to the size of the cells. They are round in the larger cells, and ovoid or oval in the smaller. They are densely chromatic and stain intensely; the chromatin is in the form of coarse granules with a few larger periferal granules in each nucleus.

As the bladder approaches the ventriculo-iliac bend, the circular muscles of the intestine grow out and surround it, and the lumen of the bladder soon opens directly into that of the proximal portion of the ileum. The intima of the bladder, both primary and secondary, is directly continuous with that of the ileum and, like the latter, it does not stain either with eosin or Delafield's hæmatoxylin; the intima in the bladder is somewhat thinner, and the primary intima is not pigmented. The epithelium of the two portions is continuous; the cells of the ileum are more elongate than those of the bladder, but the nuclei are of about the same size. The basement membrane is continuous. The peritoneum, which ends when the circular muscles grow out and surround the bladder, is continuous with the connective tissue sheath in which they are lodged.

There is no suggestion of an urethra, or stalk, leading from the bladder to the intestine, such as is often present, except that two of the undulatory folds of the iliac epithelium are larger where the bladder empties, and make a sort of passageway between the two lumina. Since such a stalk is present at least in *A. nemorum* (Schindler 1878; p. 631), this may represent the first step in the development of one.

The fusion of the four vessels is shown in figure 17; the fusion of the lumina of the two outer vessels, in figure 18; the complete bladder, in figure 19; and the junction of the bladder and ileum, in figure 20.

THE DISTAL PORTION OF THE ILEUM.

Transition. As soon as the bladder has emptied into the canal, the intima is gradually reduced in thickness, and the epithelial cells become thicker, with the folds larger and less acute; the nuclei also become larger, and the cytoplasm tends to become differentiated into two regions, as is explained below. This transition is gradual, not abrupt. All of the layers of the proximal portion of the ileum are continuous with those of the distal.

Intima. The intima is divided into a primary and a secondary intima, but the latter is much thinner than in the proximal portion. It becomes progressively narrower throughout this region.

Epithelium. The epithelium is composed of large, irregularly cuboidal cells, whose boundaries are frequently so indistinct that they form an apparent syncytium. In most cases there are two areas of cytoplasm clearly distinguishable: an inner (toward the basement membrane) layer, denser and darker, staining violet-pink with eosin, and an outer, more or less fibrillar, staining light pink. These areas are of about equal width. This condition (which is doubtless related to the absorption of food, since such a differentiation is not apparent unless there is food in the intestine) is most prominent proximally, but becomes less and less distinct, although it is still plainly discernible through the whole course of the ileum. The nuclei, which are quite large, may be either round or oval; they are densely chromatic, especially around the perifery and in the center. The chromatin is present in the form of coarse granules.

In some sections the epithelium appears only slightly, if at all, folded, but usually it is conspicuously and strongly thrown into tooth-like projections, typically six in number.

The distal portion of the ileum is shown in figure 21.

Basement membrane. The basement membrane is thin, but clearly distinguishable.

Longitudinal muscles. The longitudinal muscle fibres are continuous anteriorly with those of the proximal portion of the ileum, and are inserted posteriorly on the intima at the extreme end of this region. The longitudinal muscles are continuous nearly the whole length of the alimentary canal; they arise at the extreme anterior end of the pharynx and lie inside of the circular muscle sheath in the fore-intestine; they pass outside this sheath, and are external in the mid-intestine; they pass inside again at the beginning of the hind-intestine, so that they are internal, and are finally inserted on intima at the posterior end of the ileum.

Circular muscles. The striated circular muscle fibres are well developed. They lie in a connective tissue sheath continuous anteriorly with that of the proximal portion of the ileum, and posteriorly with that of the colon.

THE COLON.

Transition. The epithelium changes gradually in type between this region and the preceding. The intima, basement membrane, and circular muscles are also continuous. The longitudinal muscles of the ileum disappear, as they are inserted on the intima at the end of the ileum, and a new layer of much larger longitudinal muscle fibres, external and not internal, appears, inserted on the intima at the beginning of this region.

Intima. The intima is slightly thicker than it was in the ileum; like the latter, it is differentiated into a primary and a secondary intima, the former being very thin.

Epithelium. At the point of union between the colon and the ileum, the epithelial cells of one region closely resemble those of the other. The intestine bends again caudad at the junction, and a section through this region shows at one side typical ileum cells and at the other typical colon cells, while between them are transition cells which might be assigned to either region. The cells of the ileum nearly always show a differentiation into two areas of cytoplasm, while the cytoplasm of the colon cells is only rarely so differentiated, this differentiation usually disappearing in the intervening transitional cells. There is at this point no difference in the size of the cells.

As one traces the course of the colon toward the rectum, the cells of the epithelium become flatter and flatter, this tendency beginning with the association of the Malpighian vessels with the wall of the canal. Typically, the epithelium of the colon is only about one-half as high as that of the ileum, though the cells are nearly if not quite as wide. The cytoplasm is usually of the same structure throughout, resembling the inner layer of the ileum, but rarely it is feebly differentiated into two layers as is the case in the ileum.

The nuclei are of about the same size and shape as in the preceding region, but the chromatin granules are slightly larger. Here, too, the cell divisions are obscure, probably in part at least due to the fixation. The epithelium may be unfolded, or may be thrown into six or more prominent tooth-like folds, which project into the lumen.

A typical cross-section through the colon is shown in figure 25.

Basement membrane. The basement membrane is always clearly defined.

Circular muscles. The layer of circular muscles, which is continuous with that of the ileum, is strongly developed in the anterior portion of the colon, but the fibres become weaker and weaker as one traces them caudad, although they do not disappear completely until the end of this region. The most posterior muscle is inserted on the intima of the colon, on an apodeme-like projection between the colon and rectum. Like the other circular muscle fibres, they lie in a connective tissue sheath. This sheath forms a continuous tube around the alimentary canal from the anterior end of the pharynx through the posterior end of the colon.

Longitudinal muscles. New and very strong longitudinal muscle fibres appear with the colon. They lie outside the circular muscles, not inside like the longitudinal muscles of the ileum. They begin at the point where sections through the ileo-colonic bend first show signs of the approaching constriction and separation. At their origin, they are inserted on the intima of this region. There are six of these longitudinal muscle fibres, arranged quite regularly in a typical cross section. Three of these muscles appear on the outer (left) side as soon as there is any sign of the constriction referred to above, and three are developed on the inner (right) as soon as the colon and ileum have separated. These muscles grow gradually smaller and are inserted on the intima slightly anterior to the end of the colon.

Peritoneum and Malpighian vessels. The distal ends of the Malpighian vessels are closely associated with the walls of the colon. The fusion of the Malpighian vessels into two common trunks at the end of their "coelomic" course has been pointed out already (page 298). Each trunk applies itself closely to the wall of the colon, one dorsally and one ventrally, each lying between two of the longitudinal fibres; they join the canal as soon as these fibres have been developed. As soon as the vessels have become appressed to the wall of the colon, their peritoneal sheaths grow out and join, so that a continuous peritoneal coat is formed, which completely surrounds the colon, and encloses the six muscle fibres and the two Malpighian trunks.

As soon as this tunic is complete, or even before, each trunk (which is not larger than an ordinary Malpighian tube) redivides into three vessels, which almost immediately begin to "migrate" outside the muscle fibres, so as to lie alternately with them. This "slipping" or "migration" extends through about twenty sections of six micra each before it is completed. The condition which results characterizes the greater part of the colon, and in a typical cross-section, one will find lying outside the circular muscles, a layer composed of the six longitudinal muscle fibres.

alternating with the six Malpighian vessels, the whole surrounded by a nucleated peritoneum, which is a double layer, since it represents the investing sheath of the vessels. The two sheets separate at the vessels, one layer passing inside and the other outside of the tubes, but both sheets pass outside of the longitudinal muscles.

Normally the two trunks do not join the colon opposite one another as would be expected; at least, this is the case in every series which the writer has examined. The ventral trunk occupies what may be termed the normal position, and when it redivides into three vessels, the central vessel remains in position and each of the two lateral ones migrates around the adjacent muscle fibre. The dorsal trunk, however, does not enter exactly opposite (i. e., with three muscles intervening), but slightly to one side of the canal (i. e., with but two muscles intervening). Therefore when it redivides, it is the innermost vessel which remains in place; the outermost not only must slip outside the adjacent muscle fibre, but must also pass the next one beyond, so that in its migration it slips outside of two muscles before it is in position; the middle vessel slips outside a single fibre, the one originally adjacent to the outermost vessel, and then it is in place. Thus is brought about the regular alternation of muscle fibre and Malpighian vessels, which obtained in every instance which the writer has observed.

In the anterior part of the colon the cross-sections of the Malpighian vessels and of the longitudinal muscles are about equal in diameter. But as they pass caudad, the Malpighian vessels gradually increase in size, while the longitudinal muscles become weaker, and two-thirds caudad the Malpighian tubes are twice as large as the muscles. At this point the longitudinal muscles begin to diminish in size rapidly, and become very small, although they persist faintly to the end of the region. The circular muscles also decrease so markedly in size as to be almost negligible. The Malpighian vessels, which have been almost circular in cross-sections, now become elongated along the diameter perpendicular to the axis of the canal, and tend to crowd the longitudinal muscles inside. This tendency becomes more and more pronounced, and a little distance before the end of the colon the intestine is surrounded by a practically continuous layer of Malpighian tubes, with the small longitudinal muscles intercalated between them. The vessels do not extend along the wall of the rectum, but terminate blindly at the extreme posterior end of the colon.

It is very difficult to make out the exact course of the vessels in the wall of the colon. They seem to extend posteriorly as six parallel tubes, at first of slight diameter and almost straight, but as the diameter increases, they become more and more wavy, with larger and larger folds. It is this character which makes the tubes appear so elongate in cross-section. Toward the end of the colon, these undulatory folds are so large that those of one series almost touch those of the adjacent series, and thus they almost completely surround the wall of the colon. The vessels seem to branch irregularly, the tubes terminating blindly and separately in irregular ramifications, just anterior to the strong circular muscles which appear abruptly, and mark externally the beginning of the rectum.

The writer has already figured the course of the vessels in the wall of the colon (Woods, 1916, figure 4); and a series of cross-sections of the colon showing the different conditions described above is illustrated in figures 22–27.

THE RECTUM.

Transition. The transition between the colon and the rectum is the most abrupt in the whole course of the alimentary canal. The Malpighian vessels and the peritoneal sheath disappear abruptly, and new circular muscles make their appearance suddenly. The epithelial cells of the colon become flatter and flatter, and the cell boundaries more and more distinct near the rectum, but the type changes quite abruptly to the glandular and eosinophile cells characteristic of the rectum.

Intima. At first there are only minute wavy folds in the intima and epithelium, but posteriorly these folds become gradually more and more pronounced, and more and more tooth-like in appearance, while the lumen becomes smaller and smaller. The typical number of these "teeth" is probably six, but they are far from regular, and there may be from five to eight. As is to be expected, the primary and secondary intima are continuous with the primary and secondary cuticula respectively, of the body wall. There is no pigment in the primary cuticula for a considerable distance beyond the rectal invagination.

At the proximal end of the rectum there is a pronounced outpushing of the intima into the body-cavity; this serves as a place for the attachment of the circular muscles of the colon, and the origin of the circular muscles of the rectum.

Epithelium. The cells of the epithelium are much smaller than those in the two sections immediately preceding the rectum, and the cell divisions are much clearer. At the bases of the chitinous folds referred to above, the epithelial cells are thin and stretched out, but at the apices they are broadened out and glandular in appearance. Because the cells are so thin at their bases, they might readily be overlooked, and this probably accounts for the fact that some writers have described the epithelium as wanting in the case of similar structures. It is, of course, evident that where there is an intima there must be underlying cells to secrete it. The cytoplasm of these cells stains deep pink with eosin, and is smooth, non-granular. The nuclei are smaller than those of the ileum and colon, and are not so chromatic. Posteriorly, the epithelium becomes more and more glandular in appearance, and these gland-like cells persist out into the otherwise unmodified hypodermis of the body-wall, with which this layer is of course continuous.

The epithelial cells elaborate a "molting-fluid" exactly as was described in the case of the fore-intestine. In larvæ fixed just after a molt, or at the time of hatching, the cells of the epithelium lie close against the intima; but they begin to secrete a fluid very soon, and in a few days there is a fibrillar-vacuolar area, which stains blue with Delafield's hæmatoxylin, separating the intima and epithelium. This fibrillar area is always clearly marked off from the true cytoplasmic cellular portion. The presence of this fibrillar portion is characteristic of the rectum, and is developed in all of the instars. The new cuticula is formed ectad of this area just before each molt. The new intima is formed not more than a day before the larva enters the ground, and the secondary intima becomes apparent on the fourth day of prepupal life. The fibrillar area extends out beyond the proctodeal invagination between the hypodermis and the cuticula in the body-wall, about to the point where pigment appears in the primary cuticula, and glandular cells of a type continuous with those of the rectum do not appear in the hypodermis beyond this point.

This fluid secreted doubtless serves as an aid in molting, as was suggested under the discussion of the œsophagus, for the intima of the whole hind-intestine, like that of the fore-intestine, is shed at each molt. This fluid is developed along the whole course of the fore-intestine, but is present only in the last division of the hind-intestine. This may be due to the fact that the rest of the hind-intestine is the principal seat of absorption; the intima is much thinner, and probably slips off more easily.

A cross-section through the rectum is shown in figure 28; the rectal epithelium after a molt, in figure 29; the rectal epithelium with the fibrillar area developing, in figure 30; the rectal epithelium after the formation of the pupal intima, in figure 31; and the rectal invagination, in figure 32.

Basement membrane. The basement membrane, which is clear and well developed throughout this region, is continuous with that of the body wall.

Circular muscles. There are three distinct layers of very strong circular muscles in the rectum, each layer forming a complete ring around the alimentary canal. They have their origin on the posterior face of the apodeme-like projection from the intima at the anterior end of the rectum, and are inserted on the cuticula around the proctodeal invagination. Each layer originates and is inserted independently.

Longitudinal muscles. Longitudinal muscles are entirely lacking in the rectum.

3. THE MALPIGHIAN VESSELS.

THE GENERAL COURSE OF THE VESSELS.

From a morphological point of view, the Malpighian vessels of an insect are ectodermal structures which arise during embryonic life as evaginations of the distal end of the hind-intestine. In the larva of the alder flea-beetle, they are six in number, constituting two series of four vessels and two vessels respectively. The details of their course in the body cavity has already been pointed out (Woods, 1916), and their relation to the colon is discussed elsewhere in this paper (pages 298–302). It should be clearly understood that they do not open into the colon, and that their only connection with the lumen of the alimentary canal is at the point of their evagination.

We may summarize the distribution of the tubes in the larva as follows (beginning at the distal end): Six Malpighian vessels extend parallel to one another, running cephalad in the wall of the colon; they unite at the anterior end of this region to form two common trunks, which, leaving the wall of the intestine, split up into a single tube, and a common stem representing a pair of tubes; the single tube, which is very short and delicate, runs directly to the ventriculus, where it is inserted isolated into the wall of the intestine, just at the point where the mid-intestine joins the hind-intestine; each common stem soon splits up into two vessels, which have a long course through the body-cavity, but eventually all four unite to form a single common urinary bladder, which empties directly into the ileum, at a point a little posterior to the insertion of the two shorter tubes.

For convenience in discussing the histological structure of the tubes, the writer has spoken of that portion of the Malpighian vessels enclosed in the walls of the colon, as the "included" portion, and the part which lies free in the body cavity as the "'coelomic' " portion. This is of course a very free use of the term, for the coelome, or true body-cavity, is very much reduced in insects, and the apparent body-cavity is in reality only a greatly enlarged haemocoele, or blood sinus.

THE HISTOLOGICAL STRUCTURE OF THE VESSELS OF THE FIRST SERIES.

THE "COELOMIC" PORTION.

Proximal. Interiorly, the epithelial cells of the proximal portion of the Malpighian tubes of the larva are covered by a wide, lightly staining striated border, composed of many very fine and closely appressed striæ, beneath which is a narrow band of dense deeply-staining cytoplasm. The cell cytoplasm, which stains deep violet-pink with eosin, is very granular, and presents a more or less fibrillar aspect. The nucleus, which is proportionately large, varies in shape from elliptical to circular, and is typically basal in position. The chromatin granules are larger than those of the distal nuclei and are not so densely compacted. They occur especially around the perifery.

Vacuoles in these cells indicate a secretory activity, but the writer has not followed the secretion cycle. From the sections studied it would appear that tiny secretion vacuoles are formed between the nucleus and the basement membrane, which then migrate around the nucleus so as to lie between it and the striated border, where they fuse to form a large secretion vacuole at the tip, which causes the cell to bulge out, papilla-like, into the lumen of the tube.

The epithelial cells have a very delicate but distinct basement membrane, besides a nucleated peritoneal sheath which completely surrounds the vessels.

There is no indication of a lightly staining fibrillar area just inside of the basement membrane, as is the case in the cells of the distal portion.

Distal. The epithelial cells of the distal region of the vessels are larger than those of the proximal region and the striated border is extremely delicate. The cytoplasm stains deeply with eosin, usually a little more intensely than in the cells of the proximal portion. There is a narrow area of light fibrillar cytoplasm (which even under an oil-immersion lens looks not unlike the striated border) just within the basement membrane which here too, though delicate, is clearly distinct from the nucleated peritoneum. The rest of the cytoplasm is homogeneous, and stains intensely. There may be few or several vacuolated areas in the cells, just interior to the narrow band of dense cytoplasm, lying just inside the fibrillar area referred to above.

The nucleoplasm stains a light violet with Delafield's haematoxylin, while the coarse irregularly scattered, but densely compacted chromatin granules stain deep violet. One or two chromatic granules are usually larger than the others. The oval nuclei are of about the same size as those in the proximal portion.

Typical. In a typical cross section through one of the vessels of the first series of larval tubes there are four cells, usually not more than one or two of which will be cut through the nuclei. The nuclei are oval, large and central in position. The chromatin granules are large, rather sparse and mostly periferal.

The lumen is lined by a very narrow lightly stained striated border of very closely set striæ. Between this border and the basement membrane, four areas of cytoplasm may be distinguished, the last two very narrow and the first two of about equal width. The first area is composed of more or less reticular cytoplasm which stains deeply with eosin. The second area is made up of lighter staining, homogeneous cytoplasm, surrounding secretion vacuoles. The third area is a very narrow band of dense, intensely-stained cytoplasm. The fourth area stains lightly, and is fibrillar, seemingly composed of very fine and closely apposed striations. Outside of this area is the very delicate basement membrane and the whole tube is surrounded by a nucleated peritoneum.

The aspect of the tubes varies greatly according to the fixing fluid used, and according to the stage of secretion. The differences between the proximal and distal portions of the tubes may be exaggerated in the above account, for they do not always seem to be so well marked, but in all cases which the writer has observed, the cells of the two regions present a different microscopical aspect, and the striated border seems always to be well developed in one and almost wanting in the other. This character agrees with the description of the tubes of *Scaurus* (Tenebrionidæ), by Leger and Hagenmuller (1899), where the proximal end of the vessels is lined with conspicuous cilia, but no cilia can be detected in the distal end.

All of the cells of the "coelomic" portion agree in that they undergo cyclic changes, denoting secretory activity. The cycle is probably the same in all of the cells. While the writer has not made a careful study of the process, it seems to be approximately as follows: The nuclei of the cells at first lie nearer the lumen than the basement membrane; vacuoles are formed between the nucleus and the basement membrane, which pass around the nucleus and lie between it and the striated border; the cell then bulges out, papilla-like, into the lumen as these small vacuoles fuse into one large one, which finally discharges its contents into the lumen of the vessel.

THE COMMON STEM.

The cells of the common stem formed after the vessels have fused in pairs, as well as those of the common trunk formed by the union of the three vessels, do not differ in appearance from those of the distal region of the vessels, as described above, except that the writer has not been able to detect any trace of the striated border.

The Histological Structure of the Vessels of the Second Series.

The cells of the second series of tubes are considerably smaller than those of the first series, and the nuclei, which are round or oval, are much smaller. The nuclei are densely chromatic; the chromatin granules are of the same color and size as those in the nuclei of the first series. The cytoplasm stains less intensely with eosin and is pinkish rather than purple-pink. The lumen is very slight. There is a distinct basement membrane and a nucleated peritoneum.

The Vessels in the Wall of the Colon.

Both cells and nuclei of the vessels in the wall of the colon are very much smaller even than those of the second series. The nuclei, which are proportionately large, are round or oval and densely chromatic, with small dark-stained chromatin granules. The cytoplasm is homogeneous, and is not divided into areas; it stains less intensely with eosin than that of the free portion of the tubes. The writer has not been able to find any trace of a striated border lining the lumen. There is a very delicate but distinct basement membrane, and a nucleated peritoneum.

4. THE SALIVARY GLANDS OF THE LARVA.

The salivary glands of insects are not appendages of the alimentary canal, but are independent ectodermal invaginations, which open secondarily, if at all, into the mouth cavity. In the larva of the alder flea-beetle there is a single pair of these glands, more properly in this case to be called maxillary glands, which open at the inner base of the maxillæ. They are simple tubular glands, short, lying entirely within the head, usually extending along the ventral side nearly to the thoracic border, and then bending up at a sharp angle, running nearly to the dorsal body wall.

Sections through the invagination of these tubes (see figure 33) show that the chitin of the central duct (which is differentiated into a primary and a secondary layer) is continuous with the cuticula of the body wall. There is no transition between the hypodermis and the gland cells, but the glandular epithelium is developed abruptly, as soon as the invagination takes place; it is of course continuous with the perfectly unmodified hypodermis just outside.

In cross and longitudinal sections alike, it is clearly to be seen that the glands are composed of a single layer of cells around a common central duct. This chitinous duct is always clear in all of the sections which the writer has examined. The cells are large, and of the cuboidal epithelium type. The nuclei are proportionately large, round or oval, and densely chromatic; the chromatin is in the form of fine granules, except for four or five coarser granules in each nucleus. The position of the nuclei is variable, but usually they are median, or nearer the duct. The cytoplasm is reticular, and seems to consist of a fine net-work. Large vacuoles may appear in the cells, depending on the state of secretory activity.

There is a delicate limiting membrane outside, which is continuous with the basement membrane of the hypodermis.

The labial glands, which constitute the prominent salivary glands, or cephalic silk glands, of the Lepidoptera and Trichoptera, for example, are entirely absent in the larva of the alder flea-beetle, as in insects of this order generally, both larvæ and adults.

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Since so many good bibliographies of the papers dealing with the alimentary canal of insects are available the writer has included here only those papers to which actual reference has been made in the preceding discussion.

EXPLANATION OF PLATES.

PLATE XXVI.

Fig. 1. Diagrams to show the attachment of muscles to the cuticle; A, in normal condition; B, after a molt, showing the tendons.
Fig. 2. The oral invagination, longitudinal section.
Fig. 3. The musculature of the pharynx (longitudinal section).
Fig. 4. The oesophagus, cross-section.
Fig. 5. The oesophageal epithelium, normal condition.
Fig. 6. The oesophageal epithelium, premolt condition.
Fig. 7. The oesophageal epithelium, after the formation of the new intima.
Fig. 8. A portion of the crop, cross-section.
Fig. 9. The oesophageal valve, and the transition from the fore-intestine to the mid-intestine (longitudinal section).
Fig. 10. The transition in the musculature from the fore-intestine to the mid-intestine.
Fig. 11. A portion of the first division of the ventriculus, cross-section.
Fig. 12. A portion of the second division of the ventriculus, cross-section.

PLATE XXVII.

Fig. 13. The musculature of the mid-intestine, showing the transition from the first division of the ventriculus to the second. (The constriction marks the point of separation between the two divisions).
Fig. 14. The transition from the mid-intestine to the hind-intestine (longitudinal section).
Fig. 15. The transition in the musculature from the mid-intestine to the hind-intestine.
Fig. 16. The evagination of the second series of Malpighian vessels.
Fig. 17. The first stage in the formation of the bladder; the fusion of the four Malpighian vessels of the first series.
Fig. 18. The second stage in the formation of the bladder; the fusion of the lumina of the two outer vessels.
Fig. 19. The completed bladder.
Fig. 20. The entrance of the bladder into the ileum.

PLATE XXVIII.

Fig. 21. The distal portion of the ileum, cross-section.
Fig. 22. Cross-section of the colon; association of the Malpighian vessels with its walls. The ventral vessel is just coming in contact with the colon, the two vessels of the first series, with the common stem formed by their fusion, and the one vessel of the second series, with the common trunk formed by the fusion of all three, can still be seen. (A nerve separates the two vessels of the first series). The dorsal vessel is already joined to the colon, and the peritoneal sheath is beginning to extend out on each side.
Fig. 23. Cross-section of the colon; redivision of the trunks. The ventral vessel-trunk has just redivided into three vessels; the dorsal vessel-trunk has already redivided, and the vessels are beginning to migrate around the muscle fibres.
Fig. 24. Cross-section of colon: the migration of the vessels almost completed.
Fig. 25. Cross-section of colon: typical. Note the alternate arrangement of Malpighian vessels and longitudinal muscle fibres. (The upper "E" in this figure should be "C. M.")
Fig. 26. Cross-section of colon: the Malpighian vessels are increasing in size and tending to crowd the longitudinal muscles inside.

PLATE XXIX.

Fig. 27. Cross-section of colon: the Malpighian vessels have so increased in size as practically to surround the region; both longitudinal and circular muscles are much reduced.
Fig. 28. Cross-section of the rectum.
Fig. 29. A portion of the rectal epithelium, typical condition.
Fig. 30. A portion of the rectal epithelium, in the premolt condition.
Fig. 31. A portion of the rectal epithelium, just before a molt, the new intima forming.
Fig. 32. A cross-section through the rectal invagination.
Fig. 33. A cross-section through the invagination of the salivary gland.

ABBREVIATIONS USED IN THE FIGURES.

B......Basement membrane.
BLA....Bladder.
BUC....Buccal cavity.
C^1......Primary cuticula.
C^2......Secondary cuticula.
CM....Circular muscles
D......Duct of salivary gland.
E......Epithelium.
FORE..Fore-intestine.
H......Hypodermis.
HIND..Hind-intestine.
I^1......Primary intima.
I^2......Secondary intima.
I^3......New intima, forming.
LM.....Longitudinal muscles.
M......Muscle.
MID...Mid-intestine.
N......Nerve.
O......Oesophageal valve.
OE.....Oesophagus.
P......Peritoneum.
PHA...Pharynx.
PM.....Pharyngeal muscle.
R......Imaginal ring.
RC.... Replacement cell.
S......Striated border.
SC.....Sarcolemma.
T......Malpighian tube.

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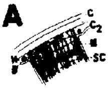

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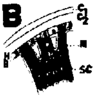

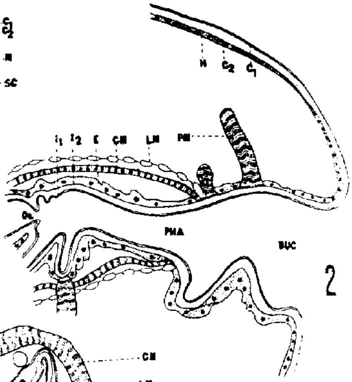

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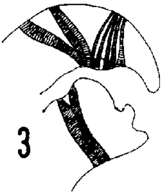

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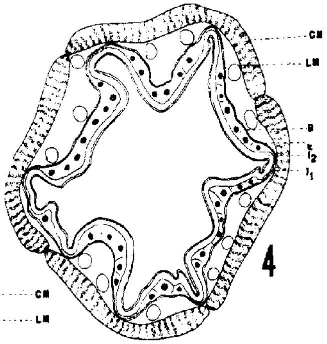

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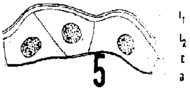

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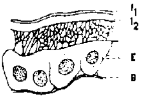

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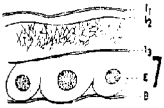

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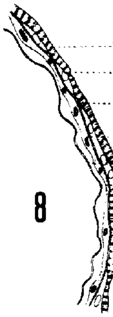

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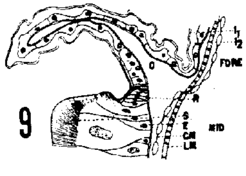

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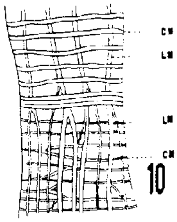

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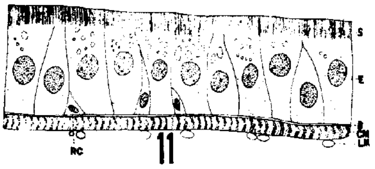

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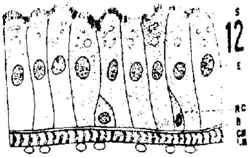

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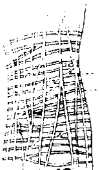
William C. Woods



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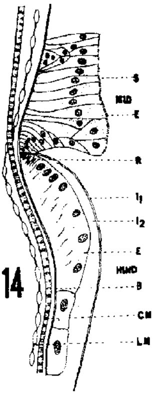

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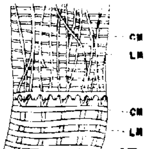

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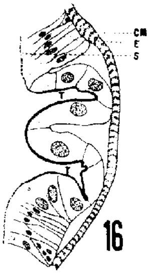

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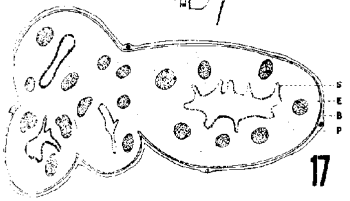

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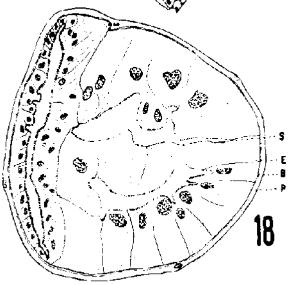

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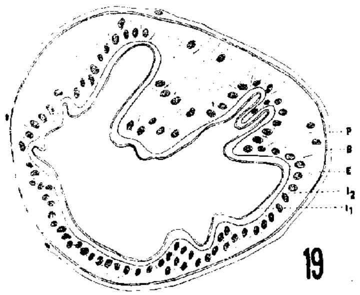

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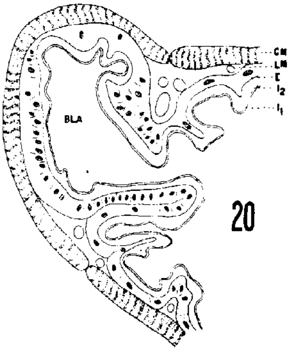

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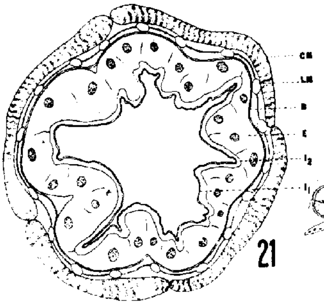
Aaron C. Woods



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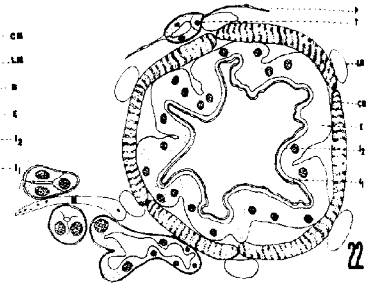

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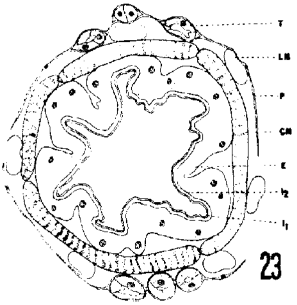

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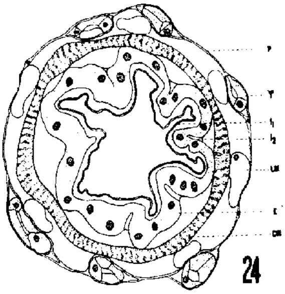

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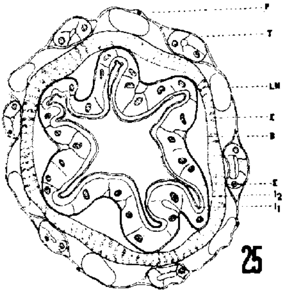

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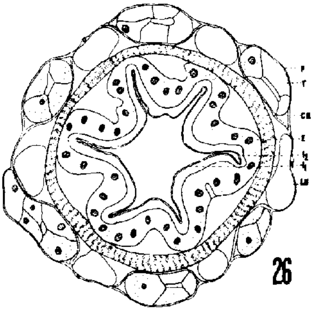

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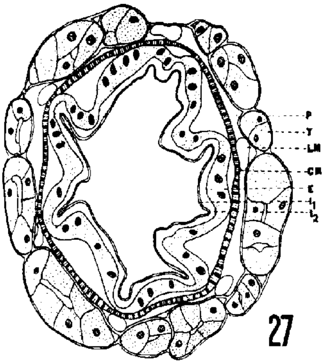
William C. Woods



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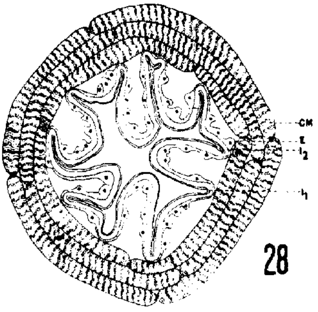

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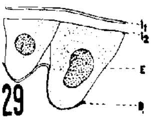

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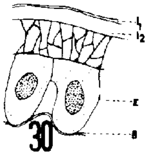

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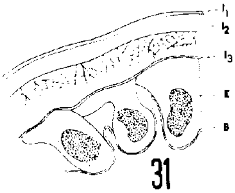

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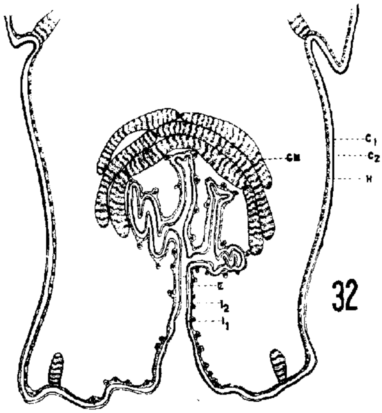

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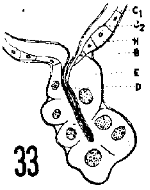

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William C. Woods